INK JET RECORDER AND DRIVING SIGNAL ADJUSTMENT METHOD THEREFOR

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Abstract

PROBLEM TO BE SOLVED: To provide an ink jet recorder where the velocity and weight of a micro dot ink droplets can be fixed even if the Helmholtz period for each recording head fluctuates.
SOLUTION: In recording heads whose Helmholtz period is large (Tc=8.0 &mu s), Twd1 is adjusted to 6.0 &mu s, 3/4 of Tc and in recording heads whose Helmholtz period is small (Tc=7.0 &mu s), Twd1 is adjusted to 7.0 &mu s equal to Tc, thereby increasing the velocity of ink droplets for, recording heads where Tc=8.0 &mu s and decreasing the velocity of ink droplets for those where Tc=7.0 &mu s. After that, by applying two different voltages, ink droplets are discharged from recording heads, the weight of discharged ink droplets is measured, and on the assumption that the weight of ink droplets changes linearly due to voltage, voltage is adjusted so that the weight of ink droplets of each head may be fixed.

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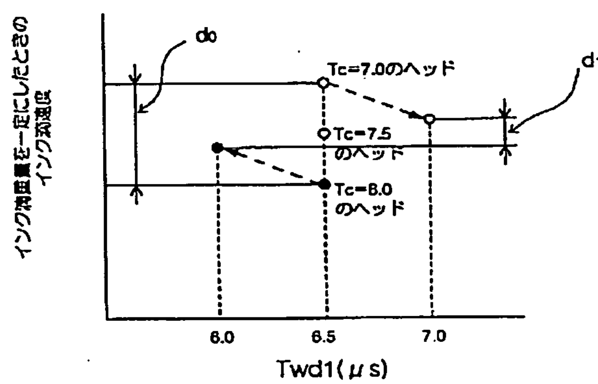
(54)【発明の名称】　インクジェット式記録装置及びその駆動信号調整方法

(57)【要約】
【課題】　記録ヘッド毎にヘルムホルツ周期がばらついても、マイクロドットのインク滴速度とインク滴重量を一定にすることができるインクジェット式記録装置を提供する。
【解決手段】　ヘルムホルツ周期が大きい（Ｔｃ＝８．０μｓ）記録ヘッドではＴｗｄ１をＴｃの３／４である６．０μｓに調整し、ヘルムホルツ周期が小さい（Ｔｃ＝７．０μｓ）記録ヘッドではＴｗｄ１をＴｃに等しい７．０μｓに調整する。これにより、Ｔｃ＝８．０μｓの記録ヘッドはインク滴の速度が大きくなり、Ｔｃ＝７．０μｓの記録ヘッドはインク滴の速度が小さくなる。その後、２点の違った電圧を印加することによって記録ヘッドからインク滴を吐出させ、それぞれの吐出されたインク滴重量を測定し、インク滴重量が電圧よって線形的に変化するものとみなして各ヘッドのインク滴重量が一定になるように電圧を調整する。



【特許請求の範囲】

【請求項１】　圧力発生手段を作動させることにより圧力発生室を収縮させてノズル開口からインク滴を吐出させるインクジェット式記録ヘッドと、

前記圧力発生室を膨張させる膨張信号と、前記ノズル開口からインク滴を吐出するように前記圧力発生室を収縮させる収縮信号とを含む駆動信号を前記圧力発生手段に出力する駆動手段と、

前記膨張信号の継続時間を変更することにより前記収縮信号で吐出されるインク滴の速度を調整する手段とを備え、

前記膨張信号によってインクのメニスカスが振動する記録ヘッド毎に固有の周期Ｔｃが大きいほど前記膨張信号の継続時間を小さくすることを特徴とするインクジェット式記録装置。

【請求項２】　前記膨張信号の継続時間はＴｃとＴｃの３／４との間で設定することを特徴とする請求項１に記載のインクジェット式記録装置。

【請求項３】　請求項１に記載のインクジェット式記録装置の駆動信号を調整する方法であって、

前記膨張信号によってインクのメニスカスが振動する記録ヘッド毎に固有の周期Ｔｃを測定する工程と、

Ｔｃが大きいほど前記膨張信号の継続時間を小さくする工程とを含むことを特徴とするインクジェット式記録装置の駆動信号調整方法。

【請求項４】　前記膨張信号の継続時間はＴｃとＴｃの３／４との間で設定することを特徴とする請求項３に記載のインクジェット式記録装置の駆動信号調整方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、同一のノズルから異なる大きさのインク滴を吐出するインクジェット式記録ヘッドを備えるインクジェット式記録装置に関するものであり、特に微小のインク滴を吐出する駆動信号の調整方法に関するものである。

【０００２】

【従来の技術】インクジェト式記録装置は、ホストコンピュータから送られた記録データを展開してなるドットパターンデータに基づいて、記録ヘッドの各ノズルからそれぞれ所定のタイミングでインク滴が吐出され、これらの各インク滴が記録用紙等の記録媒体の表面にドットを形成することにより記録を行う構成となっている。このようにインクジェット式記録装置は、インク滴を吐出するかしないか、つまりドットのオンオフ制御を行うものであるため、このままでは中間階調を記録出力することができない。

【０００３】そこで、同一のノズルから異なる重量のインク滴を吐出させ階調表現を可能とする技術も提案されている。そのようなインクジェット式記録装置として、インクを収容した圧力発生室を膨張させてインクのメニスカスを大きく後退させてから圧力発生室を収縮させてインク滴を吐出させることによりノーマルドットを生成し、インクを収容した圧力発生室をインクが吐出しないように収縮させてから膨張させることによりノーマルドットの場合よりもインクのメニスカスを大きく後退させ、その後圧力発生室を収縮させることによりノーマルドットよりも微小のインク滴を吐出させてマイクロドットを生成するものが知られている。

【０００４】圧力発生室が形成されるアクチュエータユニットは、記録ヘッド毎に製造時のばらつきが存在するので、従来は圧力発生室を膨張、収縮させるためにアクチュエータユニットの圧電振動子に印加する電圧の大きさを変化させて、吐出されるインク滴重量が一定になるようにヘッド毎に調整を行っていた。

【０００５】

【発明が解決しようとする課題】しかしながら、マイクロドットを生成する駆動方法においては、インク滴重量が一定になるように印加する電圧の大きさを調整するだけでは、メニスカスの振動の周期であるヘルムホルツ周期Ｔｃが大きい記録ヘッドの場合は、圧力発生室のコンプライアンスが大きく、圧力変化がなだらかであるためインク滴速度が上がらず飛行曲がりしやすいインク滴の吐出となってしまう。Ｔｃの小さい記録ヘッドでは、インク滴速度が大きすぎて吐出状態が不安定になる。

【０００６】マイクロドットのインク滴重量とインク滴速度を一定にするためには記録ヘッドのＴｃの精度を高くする必要があり、製造コストが高くなる、あるいは製品の歩留りが低くなるという問題があった。

【０００７】本発明の目的は、記録ヘッドのヘルムホルツ周期Ｔｃがばらついてもマイクロドットのインク滴速度とインク滴重量を一定にすることができるインクジェット式記録装置及びその駆動信号の調整方法を提供することにある。

【０００８】

【課題を解決するための手段】本発明の請求項１に記載のインクジェット式記録装置または請求項３に記載のの駆動信号調整方法によれば、圧力発生室を膨張させる膨張信号とノズル開口からインク滴を吐出するように圧力発生室を収縮させる収縮信号とを含む駆動信号を圧力発生手段に出力する駆動手段と、膨張信号の継続時間を変更することにより収縮信号で吐出されるインク滴の速度を調整する手段とを備え、膨張信号によってインクのメニスカスが振動する記録ヘッド毎に固有の周期Ｔｃが大きいほど膨張信号の継続時間を小さくするため、Ｔｃが大きいヘッドのインク滴速度を大きくし、Ｔｃが小さいヘッドのインク滴速度を小さくすることができる。

【０００９】本発明の請求項２に記載のインクジェット式記録装置または請求項４に記載のの駆動信号調整方法によれば、膨張信号の継続時間はＴｃとＴｃの３／４との間で設定するため、信号の継続時間の小さな変化で大

きくインク滴速度を調整することができる。

【００１０】

【発明の実施の形態】以下、本発明の実施例を図面に基づいて詳細に説明する。

【００１１】図２は、情報処理及びヘッド駆動電力の供給を行うプリンタ本体（以下本体と記す。）１と、制御対象となる記録ヘッド２との関係を説明するブロック図である。本体１は、インクを吐出するノズルを決定するためのデータの作成及びタイミングをとるための制御論理１０１と、ヘッドのアクチュエータを駆動するための電圧波形を生成し駆動するのに十分な電力を供給する駆動回路１０２と、コネクタ１０３とを備える。

【００１２】記録ヘッド２は、インクを吐出させるための運動エネルギーを発生させる圧電素子からなる複数のアクチュエータ２１１～２１３と、そのアクチュエータに本体からの駆動電圧を印加したりしなかったりするためのアナログスイッチ２２１～２２３と、本体１内の制御論理からのデータに従い、アクチュエータ２１１～２１３を振動させるかさせないかをアナログスイッチ２２１～２２３のＯＮ／ＯＦＦにより制御する制御論理２０１とを備える。記録ヘッド２は、プリンタ機構内のキャリッジ軸上をヘッド走査方向に移動し、ヘッド走査方向の位置に応じたデータを本体１より送られ、それによりインク滴を吐出し、印刷を行う。本体１と記録ヘッド２はフレキシブル・フラット・ケーブル（以下ＦＦＣと記す。）３で接続されている。

【００１３】図３は、記録ヘッド２の機械的構造を示す断面図である。第１の蓋部材３０は、厚さ６μｍ程度のジルコニアの薄板から構成され、その表面に一方の極となる共通電極３１が形成され、その表面に圧力発生室３２に対向するようにＰＺＴ等からなる圧電振動子３３が固定され、さらにその表面にＡｕ等の比較的柔軟な金属の層からなる駆動電極３４が形成されている。

【００１４】ここで、圧電振動子３３は第１の蓋部材３０とによりたわみ振動型のアクチュエータを形成しており、圧電振動子３３が充電されると収縮して圧力発生室３２の体積を縮める変形をし、圧電振動子が放電されると伸長して圧力発生室の体積を拡大する方向に変形するようになっている。

【００１５】スペーサ３５は、圧力発生室３２を形成するのに適した厚さ、例えば１００μｍのジルコニアなどのセラミックス板に通孔を設けて構成され、第２の蓋部材３６と第１の蓋部材３０とにより両面を封止されて圧力発生室３２を形成している。

【００１６】第２の蓋部材３６は、ジルコニアなどのセラミックス板にインク供給口３７と圧力発生室３２とを接続する連通孔３８と、ノズル開口２５と圧力発生室の端部とを接続するノズル連通孔３９とを設けて構成され、スペーサ３５の一面に固定されている。

【００１７】これら第１の蓋部材３０、スペーサ３５及び第２の蓋部材３６は、粘土状のセラミックス材料を所定の形状に成形し、これを積層して焼成することにより接着剤を使用することなくアクチュエータユニット２１を構成している。

【００１８】インク供給口形成基板４０は、アクチュエータユニット２１の固定基板を兼ねるとともに、圧力発生室３２側の一端側にリザーバ４１と圧力発生室３２とを接続するインク供給口３７が設けられ、他端側にはノズル開口２５に接続するノズル連通孔４２が設けられている。

【００１９】リザーバ形成基板４３は、図示しないインクカートリッジからのインク流入を受けるリザーバ４１と、ノズル開口２５と接続するノズル連通孔４４を設けて構成され、一方の面をノズルプレート４５により封止されてリザーバ４１を形成している。

【００２０】これらインク供給口形成基板４０、リザーバ形成基板４３及びノズルプレート４５は、各々の間に熱溶着フィルムや接着剤等の接着層４６、４７により固定され、流路ユニット２２を構成している。

【００２１】この流路ユニット２２とアクチェエータユニット２１とは、熱溶着フィルムや接着剤などの接着層４８により固定され記録ヘッド１０が構成されている。

【００２２】上記の記録ヘッド１０の構成により、圧電振動子３３を放電すると、圧力発生室３２が膨張し、圧力発生室３２内の圧力が低下してリザーバ４１から圧力発生室内にインクが流入する。圧電振動子３３を充電させると、圧力発生室３２が縮小し、圧力発生室３２内の圧力が上昇して圧力発生室３２内のインクがノズル開口２５から外部に吐出される。

【００２３】以上のような構成により印字するときの手順を図４と図５を用いて説明する。紙が固定された状態で、記録ヘッド２はヘッド走査方向に移動する。そのとき、図５のＡとＢに示すようなパルス列が、図２のＦＦＣ３を通じて本体１から記録ヘッド２に送られる。Ａは微小のインク滴を吐出させてマイクロドットを生成させる駆動パルスであり、Ｂはマイクロドットよりも大きいノーマルドットを生成させる駆動パルスである。ＡまたはＢのいずれかの駆動パルスと同期してアナログスイッチ２２１～２２３の開閉を規定するデータも本体１から記録ヘッド２に送られており、特定のパルスに対して、アナログスイッチ２２１～２２３のうちで閉じられたものに接続しているアクチュエータのみが変位する。駆動されたアクチュエータに対応する圧力発生室内のインク圧力が高められる結果、図４のノズル２５１～２５３のうち、これに対応するノズルのみからインクが吐出される。

【００２４】図５のＡに示すマイクロドットの駆動パルスは、その電圧値が中間電位ＶｍＭからスタートし（１１１）、最大電位ＶＰＭまで所定の時間Ｔｗｃ０の間に一定の勾配で上昇し（１１２）、最大電位ＶＰＭを所定

時間Ｔｗｈ０だけ維持する（１１３）。次に、マイクロドット駆動パルスは第１の最低電位ＶＬＳまで所定の時間Ｔｗｄ１の間に一定の勾配で下降し（１１４）、最低電位ＶＬＳを所定時間Ｔｗｈ１だけ維持する（１１５）。そしてマイクロドット駆動パルスの電圧値は最大電位ＶＰＭまで所定の時間Ｔｗｃ１の間に一定の勾配で再び上昇し（１１６）、最大電位ＶＰＭを所定時間Ｔｗｈ２だけ維持する（１１７）。その後、マイクロドット駆動パルスは中間電位ＶｍＭまで所定の時間Ｔｗｄ２の間に一定の勾配で下降する（１１８）。

【００２５】ここで、充電パルス１１２が圧電振動子３３に印加されると、図３の圧電振動子３３は圧力発生室３２の容積を収縮させる方向にたわみ、圧力発生室３２内に正圧を発生させる。その結果、メニスカスはノズル開口から盛り上がる。充電パルス１１２の電位差が大きく、電圧勾配が大きい場合には、充電パルス１１２によってインク滴を吐出することも可能であるが、本実施例においては充電パルス１１２によってインク滴を吐出しない範囲に充電パルス１１２の電位差を設定している。本実施例においては更に、充電パルス１１２の充電時間Ｔｗｃ０は、メニスカスヘルムホルツ周期Ｔｃの振動を誓起しないようにＴｃ以上に設定されている。

【００２６】充電パルス１１２で盛り上がったメニスカスは、ホールドパルス１１３が印加されている間に、インクの表面張力により周期Ｔｍの振動でノズル開口２５内へ戻る動きに転ずる。

【００２７】放電パルス１１４を印加すると圧電振動子３３は圧力発生室３２の容積を膨張させる方向にたわみ、圧力発生室３２内に負圧が生じる。その結果、メニスカスのノズル開口２５の内部に向かう動きが重畳されて、メニスカスはノズル開口２５の内部に大きく引き込まれる。このように、メニスカスがノズル開口２５の内部に向かうタイミングで放電パルスを印加することで、比較的小さな放電パルス１１４の電位差でもメニスカスをノズル開口２５の内部に大きく引き込むことができる。

【００２８】充電パルス１１６が印加されると圧力発生室３２に正圧が発生してメニスカスがノズル開口２５から盛り上がる。このとき、メニスカスがノズル開口２５の内部に大きく引き込まれた状態で、正圧方向の圧力変化が発生するため、吐出されるインク滴は微小なインク滴となり、マイクロドットを生成する。

【００２９】放電パルス１１８は、放電パルス１１４と充電パルス１１６で励起されたメニスカスのＴｃ振動を抑えるための放電パルスであり、Ｔｃ振動がノズル開口２５の出口に向かうタイミングでメニスカスをノズル開口２５の内部へと向かわせる放電パルス１１８を印加する。

【００３０】図５のＢに示すノーマルドットの駆動パルスは、中間電位ＶｍＮからスタートし（１２０）、第２の最低電位ＶＬＬまで一定の勾配で下降し（１２１）、最低電位ＶＬＬを所定時間だけ維持する（１２２）。そして、ノーマルドット駆動パルスの電圧値は最大電位ＶＰＮまで一定の勾配で上昇し（１２３）、最大電位ＶＰＮを所定時間だけ維持する（１２４）。その後、ノーマルドット駆動パルスは中間電位ＶｍＮまで一定の勾配で下降する。

【００３１】放電パルス１２１を印加すると、圧力発生室内に負圧が生じてメニスカスはノズル開口２５の内部に引き込まれる。ここで、放電パルス１２１の電位差を、マイクロドット駆動パルスの放電パルス１１４の電位差よりも小さく設定することで、マイクロドット駆動パルスに比べてメニスカスがノズル開口２５の内部に大きく引き込まれることはない。

【００３２】充電パルス１２３が印加されると圧力発生室３２に正圧が発生してメニスカスがノズル開口２５から盛り上がる。このとき、メニスカスがノズル開口２５の内部にそれほど引き込まれない状態で正圧方向の圧力変化が発生するため、吐出されるインク滴はマイクロドットに比べて大きなインク滴となる。

【００３３】放電パルス１２５は、放電パルス１２１と充電パルス１２３で励起されたメニスカスのＴｃ振動を抑えるための放電パルスであり、Ｔｃ振動がノズル開口２５の出口に向かうタイミングでメニスカスをノズル開口２５の内部へと向かわせる放電パルス１２５を印加する。

【００３４】記録ヘッド２がヘッド走査方向の一端から他端に移動し終わると、紙送り方向にノズル２５１～２５３の距離分だけ紙送りを行う。このようにして、プリンタの分解能によって規定される紙面上の任意の点にインクの吐出・非吐出を、記録媒体である紙の先端からの移動量、ヘッドの走査方向の位置すなわち吐出するパルスのタイミング及びノズル２５１～２５３を指定することによって定めることができる。

【００３５】ところで、前述の記録ヘッド２において、圧力発生室３２のインクの圧縮性に起因する流体コンプライアンスをＣｉ、また圧力発生室３２を形成している第１の蓋部材３０、圧電振動子３３等の材料による剛性コンプライアンスをＣｖ、ノズル開口２５のイナータンスをＭｎ、インク供給口３７のイナータンスをＭｓとすると、圧力発生室３２のヘルムホルツ共振周波数Ｆは次式で示される。

【００３６】$F=1/(2\pi)\times\sqrt{(Mn+Ms)/(Mn\times Ms)/(Ci+Cv)}$

また、メニスカスのコンプライアンスをＣｎとすると、インク流路の粘性抵抗を無視できる場合には、メニスカスの固有振動周期Ｔｍは次式で示される。

【００３７】$Tm=2\pi\times\sqrt{(Mn+Ms)Cn}$

また、圧力発生室３２の体積をＶ、インクの密度をρ、インク中での音速をｃとすると、流体コンプライアンス

Ｃｉは次式で示される。

【００３８】$Ci=V/\rho c^2$

さらに、圧力発生室３２の剛性コンプライアンスＣｖは、圧力発生室３２に単位圧力を印加したときの圧力発生室３２の静的な変形率に一致する。

【００３９】圧電振動子３３の収縮、伸長によりメニスカスに励起される振動の周期Ｔｃは、ヘルムホルツ共振周波数Ｆの逆数で得られる周期と同一である。具体例を挙げると、流体コンプライアンスＣｉが$1\times10^{-20}m^5N^{-1}$、剛性コンプライアンスＣｖが$1.5\times10^{-20}m^5N^{-1}$、イナータンスＭｎが$2\times10^8kgm^{-4}$、イナータンスＭｓが$1\times10^8kgm^{-4}$のときのヘルムホルツ共振周波数Ｆは１２５ｋＨｚであり、ヘルムホルツ周期Ｔｃは８μｓとなる。

【００４０】ヘルムホルツ周期Ｔｃは、実験室レベルでは直接測定することができるが、量産レベルで直接測定することは時間がかかるため困難である。そこで、圧力発生室３２にインクが入っていない状態でインピーダンスアナライザによって素子の共振周波数を測定する。インクが入っていない状態の共振周波数とヘルムホルツ周期Ｔｃとの間には図６に示すように比例関係があるため、共振周波数の測定値からからＴｃを計算することができる。

【００４１】記録ヘッドの製造工程において、圧力発生室３２を形成している第１の蓋部材３０、圧電振動子３３等の材料による剛性コンプライアンスＣｖ等の値には、ばらつき生じる。そのため、ヘルムホルツ周期Ｔｃもヘッド毎にばらつく。

【００４２】記録ヘッドのノズルから吐出されるインク滴の重量を各ヘッドで一定にするためには、一般にヘッド圧電振動子に印加する電圧の大きさを変化させて、吐出されるインク滴重量が一定になるようにヘッド毎に調整を行っている。具体的には２点の違った電圧でインク滴を吐出させ、それぞれの吐出されたインク滴重量を測定し、インク滴重量の変化量が電圧の変化量に比例するものとして適切なインク滴重量になるように電圧を調整する。

【００４３】しかし、マイクロドットを吐出させるときは、インク滴重量が一定になるように印加する電圧の大きさを調整するだけでは、ヘルムホルツ周期Ｔｃが大きい記録ヘッドの場合は、圧力発生室のコンプライアンスが大きく、圧力変化がなだらかであるためインク滴速度が上がらず飛行曲がりしやすいインク滴の吐出となってしまう。Ｔｃの小さい記録ヘッドでは、インク滴速度が大きすぎて吐出状態が不安定になる。

【００４４】本実施例においては、マイクロドット駆動パルスの放電パルス１１４の継続時間Ｔｗｄ１をヘルムホルツ周期Ｔｃに応じて変更することにより、インク滴の吐出速度を調整する。その原理を以下に説明する。

【００４５】図７は、ヘルムホルツ周期Ｔｃが８．０μｓの記録ヘッドにおいて、Ｔｗｄ１＝４．０μｓ、Ｔｗｄ１＝６．０μｓ、Ｔｗｄ１＝８．０μｓの３つの条件で放電パルスを圧電振動子に送り、そのまま電圧を保持したときのインクのメニスカスの振動の様子を示す図である。

【００４６】これらの記録ヘッドを用いてマイクロドットを吐出させる場合、Ｔｗｈ１を２．０μｓとすると、Ｔｗｄ１＝４．０μｓのときには、図７のＸで示すポイントで圧力発生室を収縮させる充電パルス１１６が開始される。ここでは引き込み量は最大となるが、ノズルの吐出方向に向かう速度は０となるため、インク滴速度は最大とはならない。

【００４７】Ｔｗｄ１＝６．０μｓのとき、すなわちＴｗｄ１がＴｃの３／４のときには、図７のＹで示すポイントで圧力発生室を収縮させる充電パルス１１６が開始される。ここでは、振動のノズルの吐出方向に向かう速度が最大となり、このポイントで充電パルス１１６が開始されることによる重畳効果で、インク滴重量に対するインク滴速度は最大となる。

【００４８】Ｔｗｄ１＝８．０μｓのとき、すなわちＴｗｄ１とＴｃが等しい場合には、図７のＺで示すポイントで圧力発生室を収縮させる充電パルス１１６が開始される。ここでは、メニスカスの引き込み量が小さくなり、インク滴速度は遅くなる。Ｔｗｄ１がＴｃよりも大きい場合には、メニスカスの引き込み量がさらに小さくなるので、メニスカスを大きく後退させて小さいインク滴を大きな速度で吐出させるというマイクロドットの打ち方ができなくなる。

【００４９】上記のような理由から、Ｔｗｄ１を変更したときのインク滴重量に対するインク滴速度の比は、図８に示すようにＴｗｄ１がＴｃの３／４のときに最大となる。Ｔｗｄ１がＴｃの３／４からＴｃの間では、ほぼ一定の勾配でＴｗｄ１が大きいほどインク滴速度は小さくなる。Ｔｗｄ１がＴｃより大きくなると、インク滴速度はＴｗｄ１に依らずほぼ一定となる。したがって、Ｔｗｄ１の長さを変更してインク滴速度を調整しようとする場合、Ｔｗｄ１をＴｃの３／４からＴｃの間で変更すると小さなＴｗｄ１の変更でインク滴速度を大きくすることができる。また、Ｔｗｄ１の最大値をＴｃ、最小値をＴｃの３／４とすることにより、インク滴速度の調整幅を大きくすることができる。

【００５０】ここでは一例として、表１に示すように、記録ヘッドのアクチュエータ素子の共振周波数を抜き取り測定した測定値ｆのばらつきの範囲がｆ０±１．５であり、そのときのＴｃのばらつきの範囲が６．９μｓから８．１μｓの間である場合を考える。

【００５１】

【表１】

ランク	アクチュエータ素子共振周波数（ＭＨｚ）	ヘルムホルツ周期	Ｔｗｄ１（μｓ）
A	f0-1.5≦ｆ＜f0-1.0	8.1 ≧Ｔｃ＞7.9	6.0
B	f0-1.0≦ｆ＜f0-0.5	7.9 ≧Ｔｃ＞7.7	6.2
C	f0-0.5≦ｆ＜f0	7.7 ≧Ｔｃ＞7.5	6.4
D	f0≦ｆ＜f0+0.5	7.5 ≧Ｔｃ＞7.3	6.6
E	f0+0.5≦ｆ＜f0+1.0	7.3 ≧Ｔｃ＞7.1	6.8
F	f0+1.0≦ｆ＜f0+1.5	7.1 ≧Ｔｃ＞6.9	7.0

【００５２】表１に示すように、共振周波数の測定値ｆの値によって記録ヘッドをＡ、Ｂ、Ｃ、Ｄ、Ｅ、Ｆとランク分けし、ヘルムホルツ周期Ｔｃの値を予想して記録ヘッドのＴｗｄ１を決定する。

【００５３】ここで、Ｔｗｄ１はヘルムホルツ周期Ｔｃが大きいほどＴｗｄ１が小さくなるように、かつＴｃが最も大きいランクＡにおいてはＴｃの３／４になり、Ｔｃが最も小さいランクＦにおいてはＴｃとほぼ等しくなるように決定している。

【００５４】図１は本実施例の効果を概念的に示す図である。Ｔｃ＝７．０μｓの記録ヘッド、Ｔｃ＝８．０μｓの記録ヘッドにおいて、Ｔｗｄ１を例えば６．５μｓに固定してインク滴重量が一定になるように電圧を調整すると、インク滴速度に大きな差d_0が生じる。

【００５５】本実施例によれば、Ｔｃ＝８．０μｓの記録ヘッドではＴｗｄ１をＴｃの３／４である６．０μｓに調整し、Ｔｃ＝７．０μｓの記録ヘッドではＴｗｄ１をＴｃに等しい７．０μｓに調整する。これにより、Ｔｃ＝８．０μｓの記録ヘッドはインク滴の速度が大きくなり、Ｔｃ＝７．０μｓの記録ヘッドはインク滴の速度が小さくなる。

【００５６】その後、各ヘッドから吐出されるインク滴重量が一定になるように、従来より行われている方法により、２点の違った電圧でインク滴を吐出させ、それぞれの吐出されたインク滴重量を測定し、インク滴重量が電圧に対して線形的に変化するものとみなして適切なインク滴重量になるように電圧を調整する。

【００５７】このようにして、Ｔｃにばらつきがある複数の記録ヘッドにおいて、インク滴重量を一定にしたときの記録ヘッド毎のインク滴の速度の差は図１にd_1と示すように小さくすることができる。

【００５８】以下に、本実施例において図５のＡに示す放電パルス１１４の継続時間Ｔｗｄ１を変更する方法について説明する。一般に、図９のような構成を用いることによって、図１０に示すような波形を生成することができる。図９の回路では駆動波形生成用の電源電圧であるVkに振幅がほぼ等しい波形を作り、Vkのみを変更することによって振幅を変更する。

【００５９】４００は波形生成装置であり、駆動波形の元になる波形を生成する。波形生成装置４００は例えば図１０のようにVk／２を中心とした振幅Vk／３の波形を生成する。オペアンプ３０１の非反転端子に波形生成装置４００の出力が接続されており、波形生成装置４００の出力をVk／２を中心にして３倍の非反転電圧増幅をしてトランジスタ３０２、３０３のベースに出力する。トランジスタ３０２、３０３はオペアンプ３０１により生成された電圧を電流増幅するためにプッシュプル接続をしたトランジスタであり、駆動波形が立ち上がる場合はトランジスタ３０２が負荷に応じた電流を流し、駆動波形が立ち下がる場合はトランジスタ３０３が電流を吸い込む。

【００６０】これらの抵抗が形成する回路を図１１に示す。ここで抵抗３０４と抵抗３０５は同じ大きさとし、各抵抗値をＲ３０４、Ｒ３０５、Ｒ３０６、Ｒ３０７とすれば、図１１の回路は図１２の回路と等価になる。よって、Ｒ３０７＝２×（Ｒ３０４／２＋Ｒ３０６）とすれば、駆動波形は、Vk ／２を中心として、波形生成装置４００の出力を３倍した波形となり、図１０に示すようになる。

【００６１】波形生成装置４００は例えば図１３に示すようなデジタル・アナログ・コンバータ（ＤＡＣ）である。ここで、４０１、４０２、４０３は抵抗ですべて同じ抵抗値をもち、Vkを３等分に分圧する。４０４、４０５はボルテージフォロワ接続されたオペアンプで、抵抗４０１、４０２、４０３により分圧された電位を出力する。抵抗４１１、４１２、…、４１４は等しい抵抗値をもつ抵抗である。４２１、４２２、…、４２４はスイッチであり、制御信号によりそれらのいずれか一つがＯＮになり、抵抗４１１、４１２、…、４１４により分圧された電圧のいずれかをオペアンプ４３１の非反転端子に出力する。オペアンプ４３１はボルテージフォロワであり、スイッチ４２１、４２２、…、４２４のいずれかにより発生された電圧をＤＡＣの出力とし、動的に閉じるスイッチを変化させて出力波形を得る。

【００６２】以上のようなＤＡＣによる波形生成装置４００の構成にあっては、任意のＶkに対し、図１３のスイッチ４２１が閉じた時に、最大の駆動電位であるＶkが、スイッチ４２４を閉じたときに最小の駆動電位であるＧＮＤが駆動波出力として出力される。

【００６３】図５のＡのような駆動波形において、放電パルス１１４の立ち下がりの傾斜を変化させたい場合にも、時間ステップに対するスイッチ４２１、４２２、…、４２４のスイッチングのタイミングを変えることにより、任意の立ち下がりの傾斜をもった出力波形が波形生成装置４００から得られる。このようにして、マイクロドット駆動パルスの放電パルス１１４の継続時間Ｔｗｄ１を変更することができる。

【図面の簡単な説明】

【図１】本発明実施例の効果を概念的に示す図である。

【図２】本発明実施例におけるプリンタ本体と記録ヘッドとの関係を示すブロック図である。

【図３】本発明実施例における記録ヘッドの機械的構造を示す断面図である。

【図４】本発明実施例において記録ヘッドにより印刷する行程を説明する模式図である。

【図５】Ａは本発明実施例におけるマイクロドットの駆動波形であり、Ｂは本発明実施例におけるノーマルドットの駆動波形である。

【図６】本発明実施例における記録ヘッドのアクチュエータの共振周波数と、ヘルムホルツ周期の関係を示す図である。

【図７】本発明実施例においてＴｗｄ１を変更したときのインクのメニスカスの振動の様子を示す図である。

【図８】本発明実施例においてＴｗｄ１とインク滴重量に対するインク滴速度の比との関係を示す図である。

【図９】本発明実施例の駆動波形を出力する回路を示す回路図である。

【図１０】図９の回路により出力される波形の一例を示す図である。

【図１１】図９の回路のうち抵抗が形成する回路を示す回路図である。

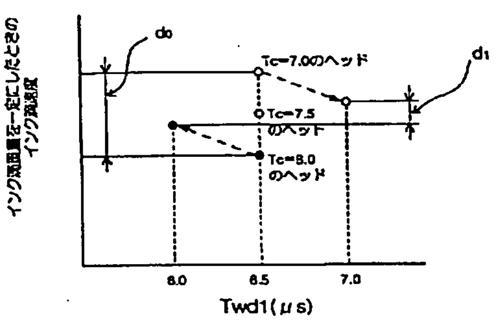
【図１２】本発明実施例において図１１の回路と等価になる回路を示す回路図である。

【図１３】本発明実施例における波形生成装置を示す回路図である。

【符号の説明】

１　プリンタ本体
２　記録ヘッド
３　フレキシブル・フラット・ケーブル
１０　記録ヘッド
２１　アクチュエータユニット
２２　流路ユニット
２５　ノズル開口
３２　圧力発生室
３３　圧電振動子（圧力発生手段）
１１２　充電パルス
１１４　放電パルス（収縮信号）
１１６　充電パルス（膨張信号）
１１８　放電パルス

【図１】



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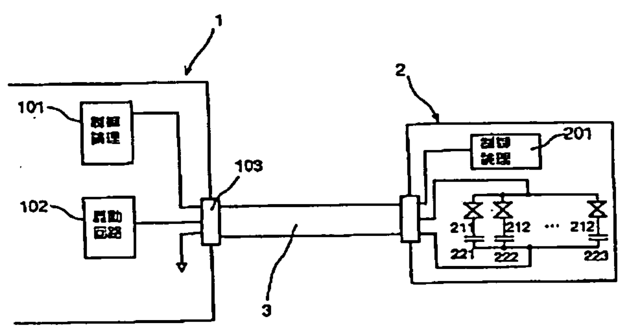
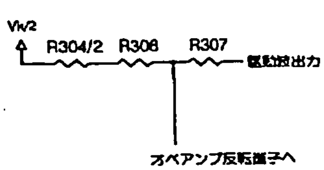


【図１２】



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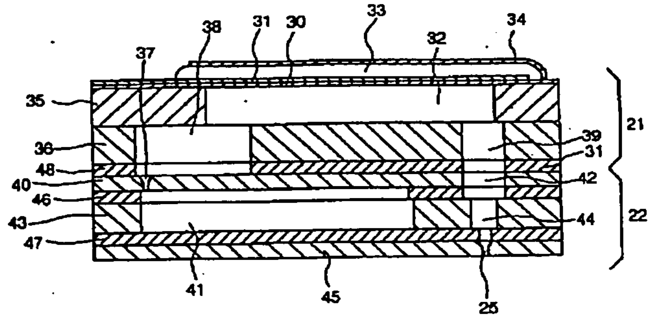

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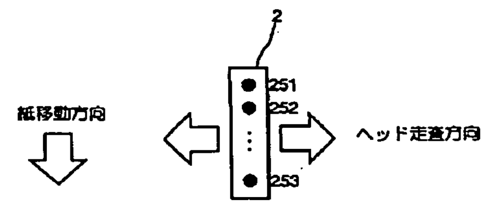

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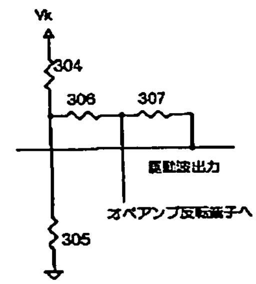

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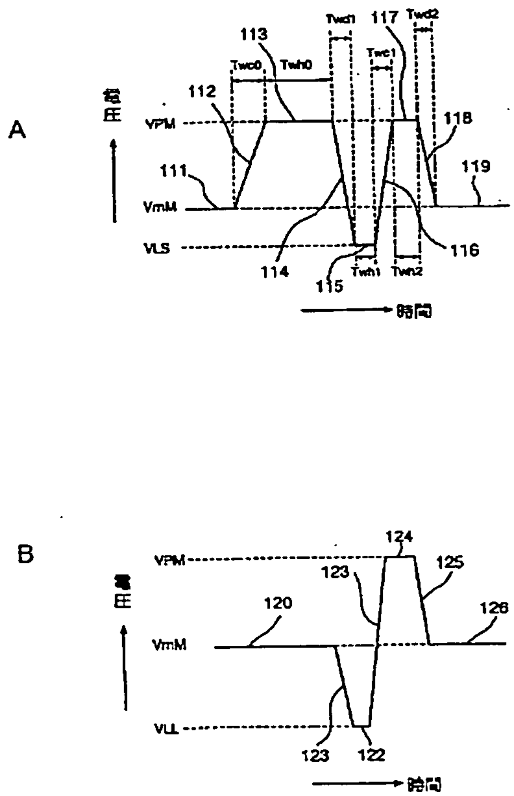

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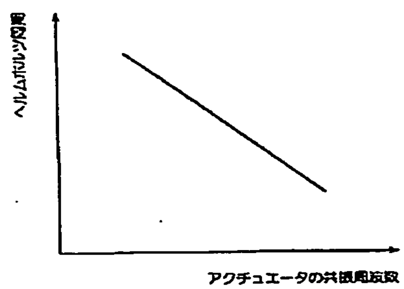

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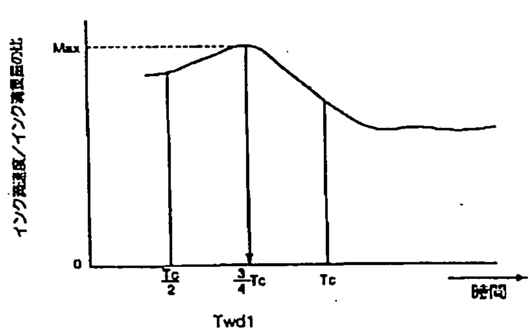

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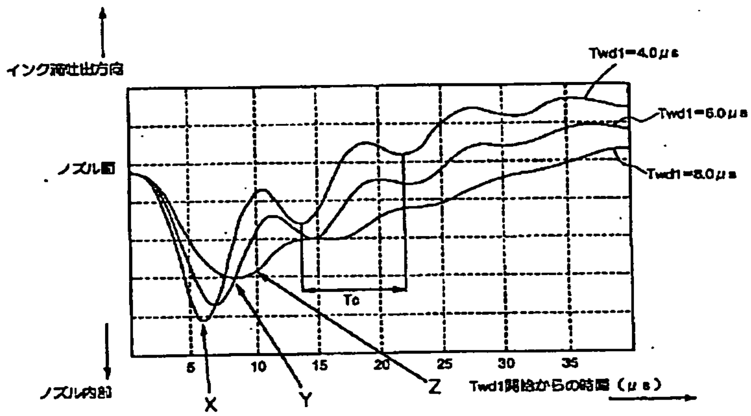
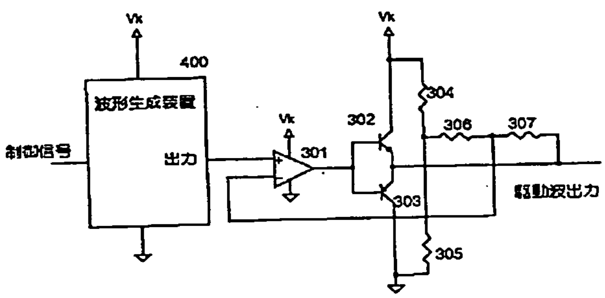
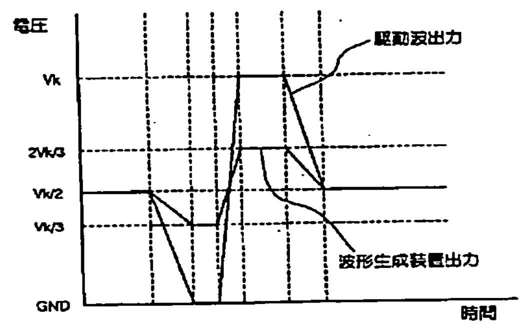

インク滴吐出方向
ノズル面
ノズル内部
Twd1=4.0μs
Twd1=6.0μs
Twd1=8.0μs
Tc
5
10
15
20
25
30
35
X
Y
Z
Twd1開始からの時間（μs）

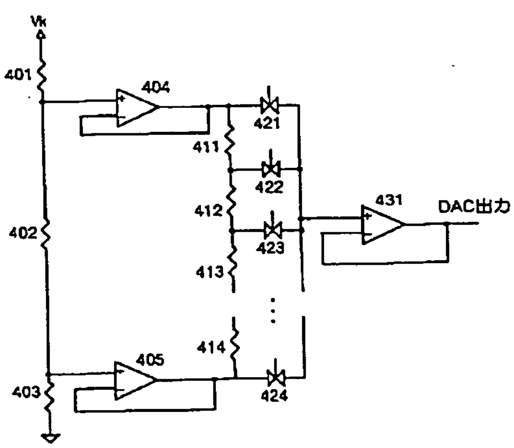
【図９】


Vk
400
波形生成装置
制御信号
出力
301
302
303
304
305
306
307
駆動波出力

【図１０】


電圧
Vk
2Vk/3
Vk/2
Vk/3
GND
駆動波出力
波形生成装置出力
時間

【図１３】


Vk
401
402
403
404
405
411
412
413
414
421
422
423
424
431
DAC出力

PATENT ABSTRACTS OF JAPAN

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B41J 2/055
B41J 2/205

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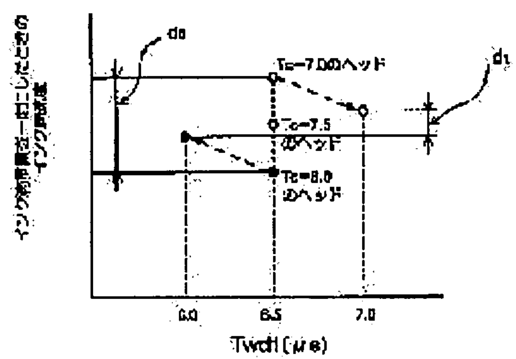
(71)Applicant : SEIKO EPSON CORP

(72)Inventor : YONEKUBO SHUJI
USUI HISAKI

(54) INK JET RECORDER AND DRIVING SIGNAL ADJUSTMENT METHOD THEREFOR

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an ink jet recorder where the velocity and weight of a micro dot ink droplets can be fixed even if the Helmholtz period for each recording head fluctuates.
SOLUTION: In recording heads whose Helmholtz period is large (Tc=8.0 μs), Twd1 is adjusted to 6.0 μs, 3/4 of Tc and in recording heads whose Helmholtz period is small (Tc=7.0 μs), Twd1 is adjusted to 7.0 μs equal to Tc, thereby increasing the velocity of ink droplets for, recording heads where Tc=8.0 μs and decreasing the velocity of ink droplets for those where Tc=7.0 μs. After that, by applying two different voltages, ink droplets are discharged from recording heads, the weight of discharged ink droplets is measured, and on the assumption that the weight of ink droplets changes linearly due to voltage, voltage is adjusted so that the weight of ink droplets of each head may be fixed.



LEGAL STATUS
[Date of request for examination] 02.07.2001

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[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The ink-jet formula recording device which is equipped with the following and characterized by making duration of the aforementioned expansion signal small for every recording head to which the meniscus of ink vibrates with the aforementioned expansion signal, so that the peculiar period Tc is large. The ink-jet formula recording head which shrinks a pressure generating room and makes an ink drop breathe out from nozzle opening by operating a pressure generating means. The expansion signal which expands the aforementioned pressure generating room. Driving means which output a driving signal including the contraction signal which shrinks the aforementioned pressure generating room so that the regurgitation of the ink drop may be carried out from the aforementioned nozzle opening to the aforementioned pressure generating means. A means to adjust the speed of the ink drop breathed out by the aforementioned contraction signal by changing the duration of the aforementioned expansion signal.
[Claim 2] The duration of the aforementioned expansion signal is an ink-jet formula recording device according to claim 1 characterized by setting up among three fourths of Tc and Tc.
[Claim 3] The driving-signal adjustment method of the ink-jet formula recording device characterized by including the process at which it is the method of adjusting the driving signal of an ink-jet formula recording device according to claim 1, and the meniscus of ink vibrates with the aforementioned expansion signal, and which measures the peculiar period Tc for every recording head, and the process which makes duration of the aforementioned expansion signal small, so that Tc is large.
[Claim 4] The duration of the aforementioned expansion signal is the driving-signal adjustment method of the ink-jet formula recording device according to claim 3 characterized by setting up among three fourths of Tc and Tc.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the adjustment method of the driving signal which carries out the regurgitation of the minute ink drop especially about an ink-jet formula recording device equipped with the ink-jet formula recording head which carries out the regurgitation of the ink drop of a size which is different from the same nozzle.
[0002]
[Description of the Prior Art] Based on the dot pattern data which come to develop the record data sent from the host computer, an ink drop is breathed out from each nozzle of a recording head to predetermined timing, respectively, and the ink JIETO formula recording device has composition which records when each of these ink drops form a dot in the front face of record media, such as a record form. Thus, since an ink-jet formula recording device is what does not carry out whether the regurgitation of the ink drop is carried out, or [that is,] performs on-off control of a dot, it cannot carry out the record output of the middle gradation with this.
[0003] Then, the technology which is made to breathe out the ink drop of a weight which is different from the same nozzle, and enables gradation expression is also proposed. A normal dot is generated by shrinking a pressure generating room and making an ink drop breathe out, since the pressure generating room in which ink was held is expanded as such an ink-jet formula recording device and the meniscus of ink is retreated greatly. The meniscus of ink is greatly retreated rather than the case of a normal dot by making it expand, after ink breathes out and twists the pressure generating room in which ink was held and making it contract like. What is made to breathe out an ink drop minuter than a normal dot, and generates a micro dot is known by shrinking a pressure generating room after that.
[0004] Since dispersion at the time of manufacture existed for every recording head, the actuator unit in which a pressure generating room is formed changed the size of the voltage impressed to the piezoelectric transducer of an actuator unit in order to expand and to shrink a pressure generating room conventionally, and it was adjusting for every head so that the ink drop weight breathed out might become fixed.
[0005]
[Problem(s) to be Solved by the Invention] However, in the drive method which generates a micro dot, the compliance of a pressure generating room will be large, when the helmholtz period Tc which is a period of vibration of a meniscus is a large recording head, since pressure variation is gently-sloping, ink drop speed will not go up only by adjusting the size of the voltage impressed so that an ink drop weight may become fixed, but it will become the regurgitation of a flight deflection plain-gauze cone ink drop. In the small recording head of Tc, ink drop speed is too large and a discharge condition becomes unstable.
[0006] In order to make regularity the ink drop weight and ink drop speed of a micro dot, precision of

Tc of a recording head needed to be made high, the manufacturing cost became high or there was a problem that the yield of a product became low.

[0007] The purpose of this invention is to offer the adjustment method of the ink-jet formula recording device which can make regularity the ink drop speed and the ink drop weight of a micro dot, and its driving signal, even if the helmholtz period Tc of a recording head varies.

[0008]

[Means for Solving the Problem] According to the driving-signal adjustment method of ******, to the ink-jet formula recording device or claim 3 of this invention according to claim 1 The driving means which output a driving signal including the contraction signal which shrinks a pressure generating room so that the regurgitation of the ink drop may be carried out from the expansion signal which expands a pressure generating room, and nozzle opening to a pressure generating means, It has a means to adjust the speed of the ink drop breathed out by the contraction signal by changing the duration of an expansion signal. Since duration of an expansion signal is made small for every recording head to which the meniscus of ink vibrates with an expansion signal so that the peculiar period Tc is large, Tc can enlarge ink drop speed of a large head, and Tc can make ink drop speed of a small head small.

[0009] According to the driving-signal adjustment method of ******, since the duration of an expansion signal is set up among three fourths of Tc and Tc, it can adjust ink drop speed to the ink-jet formula recording device or claim 4 of this invention according to claim 2 greatly by small change of the duration of a signal.

[0010]

[Embodiments of the Invention] Hereafter, the example of this invention is explained in detail based on a drawing.

[0011] Drawing 2 is a block diagram explaining the relation between the main part 1 of a printer (it is described as a main part below.) which performs supply of information processing and head drive power, and the recording head 2 used as a controlled system. A main part 1 is equipped with the drive circuit 102 which supplies sufficient power to generate and drive the voltage waveform for driving the control logic 101 for taking creation and timing of the data for determining the nozzle which carries out the regurgitation of the ink, and the actuator of a head, and a connector 103.

[0012] A recording head 2 is equipped with the control logic 201 which controls by ON/OFF of analog switches 221-223 whether actuators 211-213 are vibrated or it does not carry out according to the data from two or more actuators 211-213 which consist of a piezoelectric device which generates the kinetic energy for making ink breathe out, the analog switches 221-223 for not impressing driver voltage from a main part to the actuator, and the control logic in a main part 1. The carriage shaft top of the enclosure of a printer is moved to a head scanning direction, the data according to the position of a head scanning direction are sent from a main part 1, and a recording head 2 prints by this breathing out an ink drop. The main part 1 and the recording head 2 are connected by the flexible flat cable (it is described as Following FFC.) 3.

[0013] Drawing 3 is the cross section showing the mechanical structure of a recording head 2. The 1st covering device material 30 consists of sheet metal of a zirconia with a thickness of about 6 micrometers, the common electrode 31 used as one pole is formed in the front face, the piezoelectric transducer 33 which consists of PZT etc. is fixed so that the front face may be countered at the pressure generating room 32, and the drive electrode 34 which consists of a layer of comparatively flexible metals, such as Au, is further formed in the front face.

[0014] It deforms in the direction which will develop if deformation which will contract if the piezoelectric transducer 33 forms the oscillated type actuator by the 1st covering device material 30 here and a piezoelectric transducer 33 is charged, and contracts the volume of the pressure generating

room 32 is carried out and a piezoelectric transducer discharges, and expands the volume of a pressure generating room.

[0015] A spacer 35 prepares a through-hole in ceramic boards, such as the thickness suitable for forming the pressure generating room 32, for example, a 100-micrometer zirconia etc., is constituted, has both sides closed by the 2nd covering device material 36 and the 1st covering device material 30, and forms the pressure generating room 32.

[0016] the free passage whose 2nd covering device material 36 connects the ink feed hopper 37 and the pressure generating room 32 to ceramic boards, such as a zirconia, -- the nozzle free passage which connects a hole 38, and the nozzle opening 25 and the edge of a pressure generating room -- a hole 39 is formed, and it is constituted and is fixed to the whole surface of a spacer 35

[0017] The covering device material 30 of these 1st, a spacer 35, and the 2nd covering device material 36 fabricate a ceramic clay-like material in a predetermined configuration, and they constitute the actuator unit 21, without using adhesives by carrying out the laminating of this and calcinating it.

[0018] the nozzle free passage which the ink feed hopper 37 which connects a reservoir 41 and the pressure generating room 32 to the end side by the side of the pressure generating room 32 is formed, and is connected to the nozzle opening 25 at an other end side while the ink feed-hopper formation substrate 40 serves as the fixed substrate of the actuator unit 21 -- the hole 42 is formed

[0019] the reservoir 41 which receives the ink inflow from the ink cartridge which does not illustrate the reservoir formation substrate 43, and the nozzle free passage linked to the nozzle opening 25 -- a hole 44 is formed, it is constituted, a nozzle plate 45 closes one field, and the reservoir 41 is formed

[0020] The glue lines 46 and 47, such as a heat welding film and adhesives, are fixed in between [each], and these ink feed-hopper formation substrate 40, the reservoir formation substrate 43, and the nozzle plate 45 constitute the passage unit 22.

[0021] This passage unit 22 and the bitter taste CHIEETA unit 21 are fixed by the glue lines 48, such as a heat welding film and adhesives, and the recording head 10 is constituted.

[0022] By composition of the above-mentioned recording head 10, if a piezoelectric transducer 33 is discharged, the pressure generating room 32 will expand, the pressure in the pressure generating room 32 will decline, and ink will flow into the pressure generating interior of a room from a reservoir 41. If a piezoelectric transducer 33 is made to charge, the pressure generating room 32 will contract, the pressure in the pressure generating room 32 will rise, and the ink in the pressure generating room 32 will be breathed out by the nozzle opening 25 shell exterior.

[0023] The procedure when printing by the above composition is explained using drawing 4 and drawing 5 . Where paper is fixed, a recording head 2 moves to a head scanning direction. A pulse train as shown in A and B of drawing 5 is then sent to a recording head 2 from a main part 1 through FFC3 of drawing 2 . A is a driving pulse which makes a minute ink drop breathe out and makes a micro dot generate, and B is a driving pulse which makes a larger normal dot than a micro dot generate. The data which specify opening and closing of analog switches 221-223 synchronizing with the driving pulse of either A or B are also sent to the recording head 2 from the main part 1, and only the actuator linked to what was closed among analog switches 221-223 displaces them to a specific pulse. As a result of heightening the ink pressure of the pressure generating interior of a room corresponding to the driven actuator, ink is breathed out only from the nozzle corresponding to this among the nozzles 251-253 of drawing 4 .

[0024] The voltage value starts the driving pulse of the micro dot shown in A of drawing 5 from the middle potential VmM (111), it goes up with fixed inclination between the predetermined time Twc0 to the maximum potential VPM (112), and only a predetermined time Twh0 maintains the maximum potential VPM (113). Next, a micro dot driving pulse descends with fixed inclination between the predetermined time Twd1 to the 1st minimum potential VLS (114), and only a predetermined time

Twh1 maintains the minimum potential VLS (115). And the voltage value of a micro dot driving pulse rises again with fixed inclination between the predetermined time Twc1 to the maximum potential VPM (116), and only a predetermined time Twh2 maintains the maximum potential VPM (117). Then, a micro dot driving pulse descends with fixed inclination between the predetermined time Twd2 to the middle potential VmM (118).

[0025] Here, if the charge pulse 112 is impressed to a piezoelectric transducer 33, the piezoelectric transducer 33 of drawing 3 will bend in the direction which shrinks the capacity of the pressure generating room 32, and will generate positive pressure in the pressure generating room 32. Consequently, a meniscus rises from nozzle opening. The potential difference of the charge pulse 112 is large, when voltage inclination is large, although it is also possible to carry out the regurgitation of the ink drop by the charge pulse 112, in this example, the ink drop was breathed out and twisted by the charge pulse 112, and the potential difference of the charge pulse 112 is set as the range. In this example, further, the charging time Twc0 of the charge pulse 112 calls forth vibration of the meniscus helmholtz period Tc, and it is set up more than Tc so that there may be nothing.

[0026] The meniscus which rose by the charge pulse 112 is changed to the movement which returns into the nozzle opening 25 by vibration of a period Tm with the surface tension of ink, while the hold pulse 113 is impressed.

[0027] If the electric discharge pulse 114 is impressed, a piezoelectric transducer 33 will bend in the direction which expands the capacity of the pressure generating room 32, and negative pressure will produce it in the pressure generating room 32. Consequently, it is superimposed on the movement which goes to the interior of the nozzle opening 25 of a meniscus, and a meniscus is greatly drawn in the interior of the nozzle opening 25. Thus, a meniscus can be greatly drawn in the interior of the nozzle opening 25 also by the potential difference of the comparatively small electric discharge pulse 114 by impressing an electric discharge pulse to the timing to which a meniscus goes to the interior of the nozzle opening 25.

[0028] If the charge pulse 116 is impressed, positive pressure will occur in the pressure generating room 32, and a meniscus will rise from the nozzle opening 25. At this time, where a meniscus is greatly drawn in the interior of the nozzle opening 25, since the pressure variation of the positive pressure direction occurs, the ink drop breathed out turns into a minute ink drop, and generates a micro dot.

[0029] The electric discharge pulse 118 is an electric discharge pulse for suppressing Tc vibration of the meniscus excited by the electric discharge pulse 114 and the charge pulse 116, and impresses the electric discharge pulse 118 which makes a meniscus go to the interior of the nozzle opening 25 to the timing to which Tc vibration goes to the outlet of the nozzle opening 25.

[0030] The driving pulse of the normal dot shown in B of drawing 5 is started from the middle potential VmN (120), it descends with inclination fixed to the 2nd minimum potential VLL (121), and only a predetermined time maintains the minimum potential VLL (122). And the voltage value of a normal dot driving pulse rises with inclination fixed to the maximum potential VPN (123), and only a predetermined time maintains the maximum potential VPN (124). Then, a normal dot driving pulse descends with inclination fixed to the middle potential VmN.

[0031] If the electric discharge pulse 121 is impressed, negative pressure will arise in the pressure generating interior of a room, and a meniscus will be drawn in the interior of the nozzle opening 25. Here, compared with a micro dot driving pulse, a meniscus is not greatly drawn in the interior of the nozzle opening 25 by setting up the potential difference of the electric discharge pulse 121 smaller than the potential difference of the electric discharge pulse 114 of a micro dot driving pulse.

[0032] If the charge pulse 123 is impressed, positive pressure will occur in the pressure generating room 32, and a meniscus will rise from the nozzle opening 25. Since the pressure variation of the

positive pressure direction occurs in the state where a meniscus is not drawn so much in the interior of the nozzle opening 25, at this time, the ink drop breathed out turns into a big ink drop compared with a micro dot.

[0033] The electric discharge pulse 125 is an electric discharge pulse for suppressing Tc vibration of the meniscus excited by the electric discharge pulse 121 and the charge pulse 123, and impresses the electric discharge pulse 125 which makes a meniscus go to the interior of the nozzle opening 25 to the timing to which Tc vibration goes to the outlet of the nozzle opening 25.

[0034] If a recording head 2 finishes moving to the other end from the end of a head scanning direction, an ejection will be performed in the direction of an ejection by the distance of nozzles 251-253. Thus, it can set by specifying the timing and the nozzles 251-253 of the position of the scanning direction of the movement magnitude from the nose of cam of the paper which is a record medium about the regurgitation and the non-regurgitation of ink, and a head, i.e., the pulse which carries out the regurgitation, to be the arbitrary points on the space specified with the resolution of a printer.

[0035] By the way, in the above-mentioned recording head 2, when the inertance of Mn and the ink feed hopper 37 is set [the rigid compliance by the 1st covering device material 30 which forms Ci and the pressure generating room 32 for the fluid compliance resulting from the compressibility of the ink of the pressure generating room 32, and the material of piezoelectric-transducer 33 grade] to Ms for the inertance of Cv and the nozzle opening 25, the helmholtz resonance frequency F of the pressure generating room 32 is shown by the following formula.

[0036] F-1/(2pi) xroot {(Mn+Ms)/(MnxMs)/(Ci+Cv)}

Moreover, if compliance of a meniscus is set to Cn, when the viscous drag of ink passage can be disregarded, the natural-vibration period Tm of a meniscus is shown by the following formula.

[0037] Tm=2pixroot {(Mn+Ms)Cn}

Moreover, when acoustic velocity in the inside of rho and ink is set [the volume of the pressure generating room 32] to c for the density of V and ink, the fluid compliance Ci is shown by the following formula.

[0038] The rigid compliance Cv of the pressure generating room 32 is in agreement with Ci=V/rho c2 pan at the static reduction of area of the pressure generating room 32 when impressing a unit pressure at the pressure generating room 32.

[0039] Period-of-vibration Tc excited by the meniscus by contraction of a piezoelectric transducer 33 and extension is the same as that of the period obtained by the inverse number of the helmholtz resonance frequency F. If an example is given, for 2x108kgm-4 and Inertance Ms, 1x10-20m5N-1 and the rigid compliance Cv of the helmholtz resonance frequency F at the time of being 1x108kgm-4 will be [the fluid compliance Ci / 1.5x10-20m5N-1 and Inertance Mn] 125kHz, and the helmholtz period Tc will be set to 8 microseconds.

[0040] Although the helmholtz period Tc can be measured directly on laboratory level, for this reason [time], measuring directly on mass-production level is difficult the period. Then, the resonance frequency of an element is measured with an impedance analyzer in the state where ink is not contained in the pressure generating room 32. since proportionality is between the resonance frequency in the state where ink is not contained, and the helmholtz period Tc as shown in drawing 6 -- from the measured value of resonance frequency -- since -- Tc is calculable

[0041] In the manufacturing process of a recording head, it is varied and generated in values, such as the rigid compliance Cv by the 1st covering device material 30 which forms the pressure generating room 32, and the material of piezoelectric-transducer 33 grade. Therefore, the helmholtz period Tc varies for every head.

[0042] In order to make regularity the weight of the ink drop breathed out from the nozzle of a

recording head with each head, the size of the voltage generally impressed to a head piezoelectric transducer is changed, and it is adjusting for every head so that the ink drop weight breathed out may become fixed. An ink drop is made to specifically breathe out on the different voltage of two points, each breathed-out ink drop weight is measured, and voltage is adjusted so that it may become an ink drop weight suitable as that to which the variation of an ink drop weight is proportional to the amount of changes of potential.

[0043] However, when making a micro dot breathe out, the compliance of a pressure generating room will be large, when the helmholtz period Tc is a large recording head, since pressure variation is gently-sloping, ink drop speed will not go up only by adjusting the size of the voltage impressed so that an ink drop weight may become fixed, but it will become the regurgitation of a flight deflection plain-gauze cone ink drop. In the small recording head of Tc, ink drop speed is too large and a discharge condition becomes unstable.

[0044] In this example, the regurgitation speed of an ink drop is adjusted by changing the duration Twd1 of the electric discharge pulse 114 of a micro dot driving pulse according to the helmholtz period Tc. The principle is explained below.

[0045] Drawing 7 is drawing showing the situation of vibration of the meniscus of ink when the helmholtz period Tc sends an electric discharge pulse to a piezoelectric transducer on three conditions, 1= 4.0 microseconds of Twd(s), 1= 6.0 microseconds of Twd(s), and 1= 8.0 microseconds of Twd(s), and holds voltage as it was in the recording head for 8.0 microseconds.

[0046] If Twh1 is set to 2.0 microseconds when making a micro dot breathe out using these recording heads, at the time of 1= 4.0 microseconds of Twd(s), the charge pulse 116 which shrinks a pressure generating room on the point shown by X of drawing 7 will be started. Although it draws and an amount serves as the maximum here, since the speed which goes to the discharge direction of a nozzle is set to 0, in ink drop speed, the maximum does not become.

[0047] When it is 3/4 of Tc at the time 1 of 1= 6.0 microseconds of Twd(s), i.e., Twd, the charge pulse 116 which shrinks a pressure generating room on the point shown by Y of drawing 7 is started. Here, the speed which goes to the discharge direction of the nozzle of vibration serves as the maximum, and the ink drop speed to an ink drop weight serves as the maximum by the crowdedness effect by the charge pulse 116 being started on this point.

[0048] When equal at the time of 1= 8.0 microseconds of Twd(s), i.e., Twd1 and Tc, the charge pulse 116 which shrinks a pressure generating room on the point shown by Z of drawing 7 is started. Here, the amount of drawing in of a meniscus becomes small, and ink drop speed becomes slow. Since the amount of drawing in of a meniscus becomes still smaller when Twd1 is larger than Tc, a meniscus is retreated greatly and the stroke of the micro dot of making a small ink drop breathe out at a big speed becomes impossible.

[0049] Since it is above, the ratio of ink drop speed to the ink drop weight when changing Twd1 serves as the maximum, when Twd1 is 3/4 of Tc, as shown in drawing 8 . With the inclination of simultaneously regularity of Twd1 from 3/4 of Tc to Tc, ink drop speed becomes small, so that Twd1 is large. If Twd1 becomes larger than Tc, ink drop speed will not depend on Twd1, but will become almost fixed. Therefore, when the length of Twd1 tends to be changed and it is going to adjust ink drop speed, if Twd1 is changed between 3/4 of Tc, and Tc, ink drop speed can be enlarged by small change of Twd1. Moreover, span of adjustable range of ink drop speed can be enlarged by setting maximum of Twd1 to Tc and setting the minimum value to three fourths of Tc.

[0050] Here, as an example, as shown in Table 1, the case where the range of dispersion in the measured value f which sampled and measured the resonance frequency of the actuator element of a recording head is f0**1.5, and the range of dispersion in Tc at that time is for 6.9 to 8.1 microseconds is considered.

[0051]
[Table 1]

ランク	アクチュエータ素子 共振周波数（MHz）	ヘルムホルツ周期	Twd1 (μs)
A	f0-1.5≦f<f0-1.0	8.1≧Tc>7.9	6.0
B	f0-1.0≦f<f0-0.5	7.9≧Tc>7.7	6.2
C	f0-0.5≦f<f0	7.7≧Tc>7.5	6.4
D	f0≦f<f0+0.5	7.5≧Tc>7.3	6.6
E	f0+0.5≦f<f0+1.0	7.3≧Tc>7.1	6.8
F	f0+1.0≦f<f0+1.5	7.1≧Tc>6.9	7.0

[0052] As shown in Table 1, with the value of the measured value f of resonance frequency, the rank division of the recording head is carried out with A, B, C, D, E, and F, the value of the helmholtz period Tc is expected, and Twd1 of a recording head is determined.
[0053] Here, Tc was set to three fourths of Tc in the largest rank A, and Twd1 has determined that it will become almost equal to Tc in the rank F with smallest Tc so that the helmholtz period Tc is large, and Twd1 may become small.
[0054] Drawing 1 is drawing showing the effect of this example notionally. In a Tc=7.0microsecond recording head and a Tc=8.0microsecond recording head, if voltage is adjusted so that Twd1 may be fixed to 6.5 microseconds and an ink drop weight may become fixed, the big difference d0 will arise at ink drop speed.
[0055] According to this example, in a Tc=8.0microsecond recording head, Twd1 is adjusted to 6.0 microseconds which is 3/4 of Tc, and Twd1 is adjusted to 7.0 microseconds equal to Tc by the Tc=7.0microsecond recording head. Thereby, as for a Tc=8.0microsecond recording head, the speed of an ink drop becomes large, and, as for a Tc=7.0microsecond recording head, the speed of an ink drop becomes small.
[0056] Then, voltage is adjusted so that the ink drop weight breathed out from each head may become fixed, and may make an ink drop breathe out on the different voltage of two points, each breathed-out ink drop weight may be measured, it may be regarded as that from which an ink drop weight changes in alignment to voltage and it may become a suitable ink drop weight by the method currently performed conventionally.
[0057] Thus, in two or more recording heads which have dispersion in Tc, the difference of the speed of the ink drop for every recording head when fixing an ink drop weight can be made small, as it is indicated in drawing 1 as d1.
[0058] Below, how to change the duration Twd1 of the electric discharge pulse 114 shown in A of drawing 5 in this example is explained. Generally, a wave as shown in drawing 10 is generable by using composition like drawing 9 . In the circuit of drawing 9 , an amplitude makes an almost equal wave to Vk which is the supply voltage for drive wave generation, and an amplitude is changed by changing only Vk.
[0059] 400 is wave generation equipment and generates the wave which becomes the origin of a drive wave. Wave generation equipment 400 generates the wave of amplitude Vk / 3 consisting mainly of Vk/2 like drawing 10 . The output of wave generation equipment 400 is connected to the noninverting

terminal of an operational amplifier 301, 3 times as many noninverting voltage amplification as this is carried out a center [Vk/2], and the output of wave generation equipment 400 is outputted to the base of transistors 302 and 303. In order that transistors 302 and 303 may carry out current amplification of the voltage generated by the operational amplifier 301, when it is the transistor which made push pull connection, and a transistor 302 passes the current according to the load when a drive wave starts and a drive wave falls, a transistor 303 absorbs current.

[0060] The circuit which these resistance forms is shown in drawing 11 . Resistance 304 and resistance 305 consider as the same size, and R304, R305, R306, R307, then the circuit of drawing 11 become the circuit and equivalence of drawing 12 about each resistance here. Therefore, R307=2x (R304/2+R306), then a drive wave turn into a wave which doubled the output of wave generation equipment 400 three focusing on Vk/2, and come to be shown in drawing 10 .

[0061] Wave generation equipment 400 is a digital analog converter (DAC) as shown in drawing 13 . Here, 401, 402, and 403 have the same resistance altogether by resistance, and pressure Vk partially to three division into equal parts. 404 and 405 are the operational amplifiers by which voltage-follower connection was made, and output the potential pressured partially by resistance 401, 402, and 403. Resistance 411, 412, --, 414 is resistance with equal resistance. 421, 422, --, 424 are switches, and any those one is turned on [it] with a control signal, and they output either of the voltage which was pressured partially by resistance 411, 412, --, 414 to the noninverting terminal of an operational amplifier 431. It is a voltage follower, an operational amplifier 431 considers voltage generated by either of the switches 421, 422, --, 424 as the output of DAC, changes the switch which closes dynamically and acquires an output wave.

[0062] Vk which is the greatest drive potential when the switch 421 of drawing 13 closes to arbitrary Vk(s), if it was in the composition of the wave generation equipment 400 by the above DACs When a switch 424 is closed, GND which is the minimum drive potential is outputted as a drive wave output.

[0063] In a drive wave like A of drawing 5 , when the inclination of falling of the electric discharge pulse 114 wants to change, an output wave with the inclination of arbitrary fallings is acquired from wave generation equipment 400 by changing the timing of the switches 421 and 422 and -- to a time step, and switching of 424. Thus, the duration Twd1 of the electric discharge pulse 114 of a micro dot driving pulse can be changed.

[Translation done.]

* NOTICES *

TECHNICAL FIELD

[The technical field to which invention belongs] this invention relates to the adjustment method of ********** which breathes out a minute ink drop especially about an ink-jet formula recording device equipped with the ** ink-jet formula recording head which breathes out the ink drop of a size which is different from the same nozzle.

[Translation done.]

PRIOR ART

[Description of the Prior Art] Based on the dot pattern data which come to develop the record data sent from the host computer, an ink drop is breathed out from each nozzle of a recording head to predetermined timing, respectively, and the ink JIETO formula recording device has composition which records when each of these ink drops form a dot in the front face of record media, such as a record form. Thus, since an ink-jet formula recording device is ** which breathes out an ink drop, or a thing which does not carry out or [that is,] performs on-off control of a dot, it cannot carry out the record output of the middle gradation with this.
[0003] Then, the technology which is made to breathe out the ink drop of a weight which is different from the same nozzle, and enables gradation expression is also proposed. Since the pressure generating room in which ink was held is expanded as such an ink-jet formula recording device and the meniscus of ink is retreated greatly, a pressure generating room is shrunk and an ink drop is made to breathe out. What the meniscus of ink is greatly retreated rather than the case of a normal dot, is made to breathe out an ink drop minuter than a normal dot by shrinking a pressure generating room after that, and generates a micro dot is known by making it expand, after generating a normal dot, and ink's breathing out and twisting the pressure generating room in which ink was held and making it contract like.
[0004] Since dispersion at the time of manufacture existed for every recording head, the actuator unit in which a pressure generating room is formed changed the size of the voltage impressed to the piezoelectric transducer of an actuator unit in order to expand and to shrink a pressure generating room conventionally, and it was adjusting for every head so that the ink drop weight breathed out might become fixed.

[Translation done.]

* NOTICES *

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, in the drive method which generates a micro dot, the compliance of a pressure generating room will be large, when the helmholtz period Tc which is a period of vibration of a meniscus is a large recording head, since pressure variation is gently-sloping, ink drop speed will not go up only by adjusting the size of the voltage impressed so that an ink drop weight may become fixed, but it will become **** of a flight deflection plain-gauze cone ink drop. In the small recording head of Tc, ink drop speed is too large and a discharge condition becomes unstable.
[0006] In order to make regularity the ink drop weight and ink drop speed of a micro dot, precision of Tc of a recording head needed to be made high, the manufacturing cost became high or there was a problem that the yield of a product became low.
[0007] The purpose of this invention is to offer the adjustment method of the ink-jet formula recording device which can make regularity the ink drop speed and the ink drop weight of a micro dot, and its driving signal, even if the helmholtz period Tc of a recording head varies.

[Translation done.]

MEANS

[Means for Solving the Problem] According to the driving-signal adjustment method of ******, to the ink-jet formula recording device or claim 3 of this invention according to claim 1 The driving means which output a driving signal including the contraction signal which shrinks a pressure generating room so that the regurgitation of the ink drop may be carried out from the expansion signal which expands a pressure generating room, and nozzle opening to a pressure generating means, It has a means to adjust the speed of the ink drop breathed out by the contraction signal by changing the duration of an expansion signal. Since duration of an expansion signal is made small for every recording head to which the meniscus of ink vibrates with an expansion signal so that the peculiar period Tc is large, Tc can enlarge ink drop speed of a large head, and Tc can make ink drop speed of a small head small.
[0009] According to the driving-signal adjustment method of ******, since the duration of an expansion signal is set up among three fourths of Tc and Tc, it can adjust ink drop speed to the ink-jet formula recording device or claim 4 of this invention according to claim 2 greatly by small change of the duration of a signal.
[0010]
[Embodiments of the Invention] Hereafter, the example of this invention is explained in detail based on a drawing.
[0011] Drawing 2 is a block diagram explaining the relation between the main part 1 of a printer (it is described as a main part below.) which performs supply of information processing and head drive power, and the recording head 2 used as a controlled system. A main part 1 is equipped with the drive circuit 102 which supplies sufficient power to generate and drive the voltage waveform for driving the control logic 101 for taking creation and timing of the data for determining the nozzle which carries out the regurgitation of the ink, and the actuator of a head, and a connector 103.
[0012] A recording head 2 is equipped with the control logic 201 which controls by ON/OFF of analog switches 221-223 whether actuators 211-213 are vibrated or it does not carry out according to the data from two or more actuators 211-213 which consist of a piezoelectric device which generates the kinetic energy for making ink breathe out, the analog switches 221-223 for not impressing driver voltage from a main part to the actuator, and the control logic in a main part 1. The carriage shaft top of the enclosure of a printer is moved to a head scanning direction, the data according to the position of a head scanning direction are sent from a main part 1, and a recording head 2 prints by this breathing out an ink drop. The main part 1 and the recording head 2 are connected by the flexible flat cable (it is described as Following FFC.) 3.
[0013] Drawing 3 is the cross section showing the mechanical structure of a recording head 2. The 1st covering device material 30 consists of sheet metal of a zirconia with a thickness of about 6 micrometers, the common electrode 31 used as one pole is formed in the front face, the piezoelectric

transducer 33 which consists of PZT etc. is fixed so that the front face may be countered at the pressure generating room 32, and the drive electrode 34 which consists of a layer of comparatively flexible metals, such as Au, is further formed in the front face.

[0014] It deforms in the direction which will develop if deformation which will contract if the piezoelectric transducer 33 forms the oscillated type actuator by the 1st covering device material 30 here and a piezoelectric transducer 33 is charged, and contracts the volume of the pressure generating room 32 is carried out and a piezoelectric transducer discharges, and expands the volume of a pressure generating room.

[0015] A spacer 35 prepares a through-hole in ceramic boards, such as the thickness suitable for forming the pressure generating room 32, for example, a 100-micrometer zirconia etc., is constituted, has both sides closed by the 2nd covering device material 36 and the 1st covering device material 30, and forms the pressure generating room 32.

[0016] the free passage whose 2nd covering device material 36 connects the ink feed hopper 37 and the pressure generating room 32 to ceramic boards, such as a zirconia, -- the nozzle free passage which connects a hole 38, and the nozzle opening 25 and the edge of a pressure generating room -- a hole 39 is formed, and it is constituted and is fixed to the whole surface of a spacer 35

[0017] The covering device material 30 of these 1st, a spacer 35, and the 2nd covering device material 36 fabricate a ceramic clay-like material in a predetermined configuration, and they constitute the actuator unit 21, without using adhesives by carrying out the laminating of this and calcinating it.

[0018] the nozzle free passage which the ink feed hopper 37 which connects a reservoir 41 and the pressure generating room 32 to the end side by the side of the pressure generating room 32 is formed, and is connected to the nozzle opening 25 at an other end side while the ink feed-hopper formation substrate 40 serves as the fixed substrate of the actuator unit 21 -- the hole 42 is formed

[0019] the reservoir 41 which receives the ink inflow from the ink cartridge which does not illustrate the reservoir formation substrate 43, and the nozzle free passage linked to the nozzle opening 25 -- a hole 44 is formed, it is constituted, a nozzle plate 45 closes one field, and the reservoir 41 is formed

[0020] The glue lines 46 and 47, such as a heat welding film and adhesives, are fixed in between [each], and these ink feed-hopper formation substrate 40, the reservoir formation substrate 43, and the nozzle plate 45 constitute the passage unit 22.

[0021] This passage unit 22 and the bitter taste CHIEETA unit 21 are fixed by the glue lines 48, such as a heat welding film and adhesives, and the recording head 10 is constituted.

[0022] By composition of the above-mentioned recording head 10, if a piezoelectric transducer 33 is discharged, the pressure generating room 32 will expand, the pressure in the pressure generating room 32 will decline, and ink will flow into the pressure generating interior of a room from a reservoir 41. If a piezoelectric transducer 33 is made to charge, the pressure generating room 32 will contract, the pressure in the pressure generating room 32 will rise, and the ink in the pressure generating room 32 will be breathed out by the nozzle opening 25 shell exterior.

[0023] The procedure when printing by the above composition is explained using drawing 4 and drawing 5 . Where paper is fixed, a recording head 2 moves to a head scanning direction. A pulse train as shown in A and B of drawing 5 is then sent to a recording head 2 from a main part 1 through FFC3 of drawing 2 . A is a driving pulse which makes a minute ink drop breathe out and makes a micro dot generate, and B is a driving pulse which makes a larger normal dot than a micro dot generate. The data which specify opening and closing of analog switches 221-223 synchronizing with the driving pulse of either A or B are also sent to the recording head 2 from the main part 1, and only the actuator linked to what was closed among analog switches 221-223 displaces them to a specific pulse. As a result of heightening the ink pressure of the pressure generating interior of a room corresponding to the driven actuator, ink is breathed out only from the nozzle corresponding to this among the nozzles

251-253 of drawing 4 .

[0024] The voltage value starts the driving pulse of the micro dot shown in A of drawing 5 from the middle potential VmM (111), it goes up with fixed inclination between the predetermined time Twc0 to the maximum potential VPM (112), and only a predetermined time Twh0 maintains the maximum potential VPM (113). Next, a micro dot driving pulse descends with fixed inclination between the predetermined time Twd1 to the 1st minimum potential VLS (114), and only a predetermined time Twh1 maintains the minimum potential VLS (115). And the voltage value of a micro dot driving pulse rises again with fixed inclination between the predetermined time Twc1 to the maximum potential VPM (116), and only a predetermined time Twh2 maintains the maximum potential VPM (117). Then, a micro dot driving pulse descends with fixed inclination between the predetermined time Twd2 to the middle potential VmM (118).

[0025] Here, if the charge pulse 112 is impressed to a piezoelectric transducer 33, the piezoelectric transducer 33 of drawing 3 will bend in the direction which shrinks the capacity of the pressure generating room 32, and will generate positive pressure in the pressure generating room 32. Consequently, a meniscus rises from nozzle opening. The potential difference of the charge pulse 112 is large, when voltage inclination is large, although it is also possible to carry out the regurgitation of the ink drop by the charge pulse 112, in this example, the ink drop was breathed out and twisted by the charge pulse 112, and the potential difference of the charge pulse 112 is set as the range. In this example, further, the charging time Twc0 of the charge pulse 112 calls forth vibration of the meniscus helmholtz period Tc, and it is set up more than Tc so that there may be nothing.

[0026] The meniscus which rose by the charge pulse 112 is changed to the movement which returns into the nozzle opening 25 by vibration of a period Tm with the surface tension of ink, while the hold pulse 113 is impressed.

[0027] If the electric discharge pulse 114 is impressed, a piezoelectric transducer 33 will bend in the direction which expands the capacity of the pressure generating room 32, and negative pressure will produce it in the pressure generating room 32. Consequently, it is superimposed on the movement which goes to the interior of the nozzle opening 25 of a meniscus, and a meniscus is greatly drawn in the interior of the nozzle opening 25. Thus, a meniscus can be greatly drawn in the interior of the nozzle opening 25 also by the potential difference of the comparatively small electric discharge pulse 114 by impressing an electric discharge pulse to the timing to which a meniscus goes to the interior of the nozzle opening 25.

[0028] If the charge pulse 116 is impressed, positive pressure will occur in the pressure generating room 32, and a meniscus will rise from the nozzle opening 25. At this time, where a meniscus is greatly drawn in the interior of the nozzle opening 25, since the pressure variation of the positive pressure direction occurs, the ink drop breathed out turns into a minute ink drop, and generates a micro dot.

[0029] The electric discharge pulse 118 is an electric discharge pulse for suppressing Tc vibration of the meniscus excited by the electric discharge pulse 114 and the charge pulse 116, and impresses the electric discharge pulse 118 which makes a meniscus go to the interior of the nozzle opening 25 to the timing to which Tc vibration goes to the outlet of the nozzle opening 25.

[0030] The driving pulse of the normal dot shown in B of drawing 5 is started from the middle potential VmN (120), it descends with inclination fixed to the 2nd minimum potential VLL (121), and only a predetermined time maintains the minimum potential VLL (122). And the voltage value of a normal dot driving pulse rises with inclination fixed to the maximum potential VPN (123), and only a predetermined time maintains the maximum potential VPN (124). Then, a normal dot driving pulse descends with inclination fixed to the middle potential VmN.

[0031] If the electric discharge pulse 121 is impressed, negative pressure will arise in the pressure

generating interior of a room, and a meniscus will be drawn in the interior of the nozzle opening 25. Here, compared with a micro dot driving pulse, a meniscus is not greatly drawn in the interior of the nozzle opening 25 by setting up the potential difference of the electric discharge pulse 121 smaller than the potential difference of the electric discharge pulse 114 of a micro dot driving pulse.
[0032] If the charge pulse 123 is impressed, positive pressure will occur in the pressure generating room 32, and a meniscus will rise from the nozzle opening 25. Since the pressure variation of the positive pressure direction occurs in the state where a meniscus is not drawn so much in the interior of the nozzle opening 25, at this time, the ink drop breathed out turns into a big ink drop compared with a micro dot.
[0033] The electric discharge pulse 125 is an electric discharge pulse for suppressing Tc vibration of the meniscus excited by the electric discharge pulse 121 and the charge pulse 123, and impresses the electric discharge pulse 125 which makes a meniscus go to the interior of the nozzle opening 25 to the timing to which Tc vibration goes to the outlet of the nozzle opening 25.
[0034] If a recording head 2 finishes moving to the other end from the end of a head scanning direction, an ejection will be performed in the direction of an ejection by the distance of nozzles 251-253. Thus, it can set by specifying the position of the scanning direction of the movement magnitude from the nose of cam of the paper which is a record medium about **** and non-**** of ink, and a head, i.e., the timing of the ** pulse to breathe out, and nozzles 251-253 to be the arbitrary points on the space specified with the resolution of a printer.
[0035] By the way, in the above-mentioned recording head 2, when the inertance of Mn and the ink feed hopper 37 is set [the rigid compliance by the 1st covering device material 30 which forms Ci and the pressure generating room 32 for the fluid compliance resulting from the compressibility of the ink of the pressure generating room 32, and the material of piezoelectric-transducer 33 grade] to Ms for the inertance of Cv and the nozzle opening 25, the helmholtz resonance frequency F of the pressure generating room 32 is shown by the following formula.
[0036] F-1/(2pi) xroot {(Mn+Ms)/(MnxMs)/(Ci+Cv)}
Moreover, if compliance of a meniscus is set to Cn, when the viscous drag of ink passage can be disregarded, the natural-vibration period Tm of a meniscus is shown by the following formula.
[0037] Tm=2pixroot {(Mn+Ms)Cn}
Moreover, when acoustic velocity in the inside of rho and ink is set [the volume of the pressure generating room 32] to c for the density of V and ink, the fluid compliance Ci is shown by the following formula.
[0038] The rigid compliance Cv of the pressure generating room 32 is in agreement with Ci=V/rho c2 pan at the static reduction of area of the pressure generating room 32 when impressing a unit pressure at the pressure generating room 32.
[0039] Period-of-vibration Tc excited by the meniscus by contraction of a piezoelectric transducer 33 and extension is the same as that of the period obtained by the inverse number of the helmholtz resonance frequency F. If an example is given, for 2x108kgm-4 and Inertance Ms, 1x10-20m5N-1 and the rigid compliance Cv of the helmholtz resonance frequency F at the time of being 1x108kgm-4 will be [the fluid compliance Ci / 1.5x10-20m5N-1 and Inertance Mn] 125kHz, and the helmholtz period Tc will be set to 8 microseconds.
[0040] Although the helmholtz period Tc can be measured directly on laboratory level, for this reason [time], measuring directly on mass-production level is difficult the period. Then, the resonance frequency of an element is measured with an impedance analyzer in the state where ink is not contained in the pressure generating room 32. since proportionality is between the resonance frequency in the state where ink is not contained, and the helmholtz period Tc as shown in drawing 6 -- from the measured value of resonance frequency -- since -- Tc is calculable

[0041] In the manufacturing process of a recording head, it is varied and generated in values, such as the rigid compliance Cv by the 1st covering device material 30 which forms the pressure generating room 32, and the material of piezoelectric-transducer 33 grade. Therefore, the helmholtz period Tc varies for every head.
[0042] In order to make regularity the weight of the ink drop breathed out from the nozzle of a recording head with each head, the size of the voltage generally impressed to a head piezoelectric transducer is changed, and it is adjusting for every head so that the ink drop weight breathed out may become fixed. An ink drop is made to specifically breathe out on the different voltage of two points, each breathed-out ink drop weight is measured, and voltage is adjusted so that it may become an ink drop weight suitable as that to which the variation of an ink drop weight is proportional to the amount of changes of potential.
[0043] However, when making a micro dot breathe out, the compliance of a pressure generating room will be large, when the helmholtz period Tc is a large recording head, since pressure variation is gently-sloping, ink drop speed will not go up only by adjusting the size of the voltage impressed so that an ink drop weight may become fixed, but it will become the regurgitation of a flight deflection plain-gauze cone ink drop. In the small recording head of Tc, ink drop speed is too large and a discharge condition becomes unstable.
[0044] In this example, the regurgitation speed of an ink drop is adjusted by changing the duration Twd1 of the electric discharge pulse 114 of a micro dot driving pulse according to the helmholtz period Tc. The principle is explained below.
[0045] Drawing 7 is drawing showing the situation of vibration of the meniscus of ink when the helmholtz period Tc sends an electric discharge pulse to a piezoelectric transducer on three conditions, 1= 4.0 microseconds of Twd(s), 1= 6.0 microseconds of Twd(s), and 1= 8.0 microseconds of Twd(s), and holds voltage as it was in the recording head for 8.0 microseconds.
[0046] If Twh1 is set to 2.0 microseconds when making a micro dot breathe out using these recording heads, at the time of 1= 4.0 microseconds of Twd(s), the charge pulse 116 which shrinks a pressure generating room on the point shown by X of drawing 7 will be started. Although it draws and an amount serves as the maximum here, since the speed which goes to the discharge direction of a nozzle is set to 0, in ink drop speed, the maximum does not become.
[0047] When it is 3/4 of Tc at the time 1 of 1= 6.0 microseconds of Twd(s), i.e., Twd, the charge pulse 116 which shrinks a pressure generating room on the point shown by Y of drawing 7 is started. Here, the speed which goes to the discharge direction of the nozzle of vibration serves as the maximum, and the ink drop speed to an ink drop weight serves as the maximum by the crowdedness effect by the charge pulse 116 being started on this point.
[0048] When equal at the time of 1= 8.0 microseconds of Twd(s), i.e., Twd1 and Tc, the charge pulse 116 which shrinks a pressure generating room on the point shown by Z of drawing 7 is started. Here, the amount of drawing in of a meniscus becomes small, and ink drop speed becomes slow. Since the amount of drawing in of a meniscus becomes still smaller when Twd1 is larger than Tc, a meniscus is retreated greatly and the stroke of the micro dot of making a small ink drop breathe out at a big speed becomes impossible.
[0049] Since it is above, the ratio of ink drop speed to the ink drop weight when changing Twd1 serves as the maximum, when Twd1 is 3/4 of Tc, as shown in drawing 8 . With the inclination of simultaneously regularity of Twd1 from 3/4 of Tc to Tc, ink drop speed becomes small, so that Twd1 is large. If Twd1 becomes larger than Tc, ink drop speed will not depend on Twd1, but will become almost fixed. Therefore, when the length of Twd1 tends to be changed and it is going to adjust ink drop speed, if Twd1 is changed between 3/4 of Tc, and Tc, ink drop speed can be enlarged by small change of Twd1. Moreover, span of adjustable range of ink drop speed can be enlarged by setting

maximum of Twd1 to Tc and setting the minimum value to three fourths of Tc.
[0050] Here, as an example, as shown in Table 1, the case where the range of dispersion in the measured value f which sampled and measured the resonance frequency of the actuator element of a recording head is f0**1.5, and the range of dispersion in Tc at that time is for 6.9 to 8.1 microseconds is considered.
[0051]
[Table 1]

ランク	アクチュエータ素子 共振周波数（MHz）	ヘルムホルツ周期	Twd1 （μs）
A	f0-1.5≦f＜f0-1.0	8.1 ≧Tc＞7.9	6.0
B	f0-1.0≦f＜f0-0.5	7.9 ≧Tc＞7.7	6.2
C	f0-0.5≦f＜f0	7.7 ≧Tc＞7.5	6.4
D	f0≦f＜f0+0.5	7.5 ≧Tc＞7.3	6.6
E	f0+0.5≦f＜f0+1.0	7.3 ≧Tc＞7.1	6.8
F	f0+1.0≦f＜f0+1.5	7.1 ≧Tc＞6.9	7.0

[0052] As shown in Table 1, with the value of the measured value f of resonance frequency, the rank division of the recording head is carried out with A, B, C, D, E, and F, the value of the helmholtz period Tc is expected, and Twd1 of a recording head is determined.
[0053] Here, Tc was set to three fourths of Tc in the largest rank A, and Twd1 has determined that it will become almost equal to Tc in the rank F with smallest Tc so that the helmholtz period Tc is large, and Twd1 may become small.
[0054] Drawing 1 is drawing showing the effect of this example notionally. In a Tc=7.0microsecond recording head and a Tc=8.0microsecond recording head, if voltage is adjusted so that Twd1 may be fixed to 6.5 microseconds and an ink drop weight may become fixed, the big difference d0 will arise at ink drop speed.
[0055] According to this example, in a Tc=8.0microsecond recording head, Twd1 is adjusted to 6.0 microseconds which is 3/4 of Tc, and Twd1 is adjusted to 7.0 microseconds equal to Tc by the Tc=7.0microsecond recording head. Thereby, as for a Tc=8.0microsecond recording head, the speed of an ink drop becomes large, and, as for a Tc=7.0microsecond recording head, the speed of an ink drop becomes small.
[0056] Then, voltage is adjusted so that the ink drop weight breathed out from each head may become fixed, and may make an ink drop breathe out on the different voltage of two points, each breathed-out ink drop weight may be measured, it may be regarded as that from which an ink drop weight changes in alignment to voltage and it may become a suitable ink drop weight by the method currently performed conventionally.
[0057] Thus, in two or more recording heads which have dispersion in Tc, the difference of the speed of the ink drop for every recording head when fixing an ink drop weight can be made small, as it is indicated in drawing 1 as d1.
[0058] Below, how to change the duration Twd1 of the electric discharge pulse 114 shown in A of drawing 5 in this example is explained. Generally, a wave as shown in drawing 10 is generable by using composition like drawing 9 . In the circuit of drawing 9 , an amplitude makes an almost equal

wave to Vk which is the supply voltage for drive wave generation, and an amplitude is changed by changing only Vk.

[0059] 400 is wave generation equipment and generates the wave which becomes the origin of a drive wave. Wave generation equipment 400 generates the wave of amplitude Vk / 3 consisting mainly of Vk/2 like drawing 10 . The output of wave generation equipment 400 is connected to the noninverting terminal of an operational amplifier 301, 3 times as many noninverting voltage amplification as this is carried out a center [Vk/2], and the output of wave generation equipment 400 is outputted to the base of transistors 302 and 303. In order that transistors 302 and 303 may carry out current amplification of the voltage generated by the operational amplifier 301, when it is the transistor which made push pull connection, and a transistor 302 passes the current according to the load when a drive wave starts and a drive wave falls, a transistor 303 absorbs current.

[0060] The circuit which these resistance forms is shown in drawing 11 . Resistance 304 and resistance 305 consider as the same size, and R304, R305, R306, R307, then the circuit of drawing 11 become the circuit and equivalence of drawing 12 about each resistance here. Therefore, R307=2x (R304/2+R306), then a drive wave turn into a wave which doubled the output of wave generation equipment 400 three focusing on Vk/2, and come to be shown in drawing 10 .

[0061] Wave generation equipment 400 is a digital analog converter (DAC) as shown in drawing 13 . Here, 401, 402, and 403 have the same resistance altogether by resistance, and pressure Vk partially to three division into equal parts. 404 and 405 are the operational amplifiers by which voltage-follower connection was made, and output the potential pressured partially by resistance 401, 402, and 403. Resistance 411, 412, --, 414 is resistance with equal resistance. 421, 422, --, 424 are switches, and any those one is turned on [it] with a control signal, and they output either of the voltage which was pressured partially by resistance 411, 412, --, 414 to the noninverting terminal of an operational amplifier 431. It is a voltage follower, an operational amplifier 431 considers voltage generated by either of the switches 421, 422, --, 424 as the output of DAC, changes the switch which closes dynamically and acquires an output wave.

[0062] Vk which is the greatest drive potential when the switch 421 of drawing 13 closes to arbitrary Vk(s), if it was in the composition of the wave generation equipment 400 by the above DACs When a switch 424 is closed, GND which is the minimum drive potential is outputted as a drive wave output.

[0063] In a drive wave like A of drawing 5 , when the inclination of falling of the electric discharge pulse 114 wants to change, an output wave with the inclination of arbitrary fallings is acquired from wave generation equipment 400 by changing the timing of the switches 421 and 422 and -- to a time step, and switching of 424. Thus, the duration Twd1 of the electric discharge pulse 114 of a micro dot driving pulse can be changed.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the effect of this invention example notionally.
[Drawing 2] It is the block diagram showing the relation of the main part of a printer and recording head in this invention example.
[Drawing 3] It is the cross section showing the mechanical structure of the recording head in this invention example.
[Drawing 4] It is a ** type view explaining the distance printed by the recording head in this invention example.
[Drawing 5] A is the drive wave of the micro dot in this invention example, and B is the drive wave of the normal dot in this invention example.
[Drawing 6] It is drawing showing the resonance frequency of the actuator of the recording head in this invention example, and the relation of a helmholtz period.
[Drawing 7] It is drawing showing the situation of vibration of the meniscus of the ink when changing Twd1 in this invention example.
[Drawing 8] It is drawing showing the relation between Twd1 and the ratio of ink drop speed to an ink drop weight in this invention example.
[Drawing 9] It is the circuit diagram showing the circuit which outputs the drive wave of this invention example.
[Drawing 10] It is drawing showing an example of the wave outputted by the circuit of drawing 9 .
[Drawing 11] It is the circuit diagram showing the circuit which resistance forms among the circuits of drawing 9 .
[Drawing 12] It is the circuit diagram showing the circuit of drawing 11 , and the circuit which becomes equivalence in this invention example.
[Drawing 13] It is the circuit diagram showing the wave generation equipment in this invention example.
[Description of Notations]
1 Main Part of Printer
2 Recording Head
3 Flexible Flat Cable
10 Recording Head
21 Actuator Unit
22 Passage Unit
25 Nozzle Opening
32 Pressure Generating Room

33 Piezoelectric Transducer (Pressure Generating Means)
112 Charge Pulse
114 Electric Discharge Pulse (Contraction Signal)
116 Charge Pulse (Expansion Signal)
118 Electric Discharge Pulse

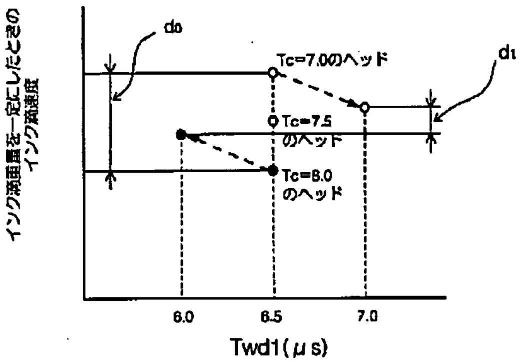
[Translation done.]

* NOTICES *

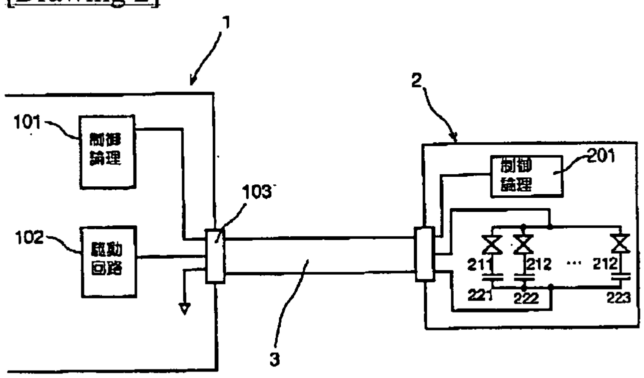
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

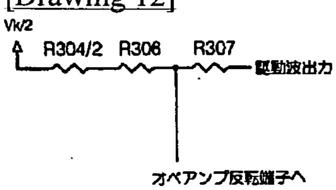
[Drawing 1]



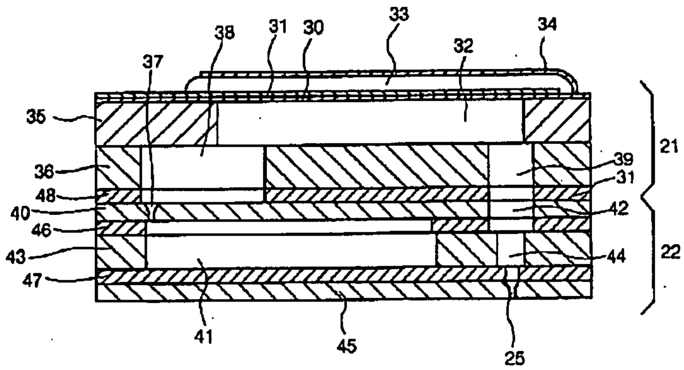
[Drawing 2]



[Drawing 12]



[Drawing 3]



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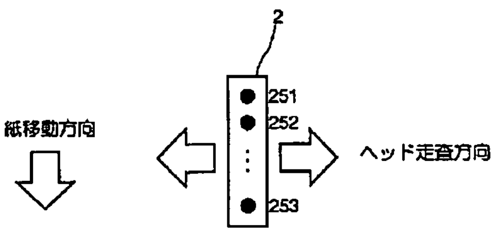
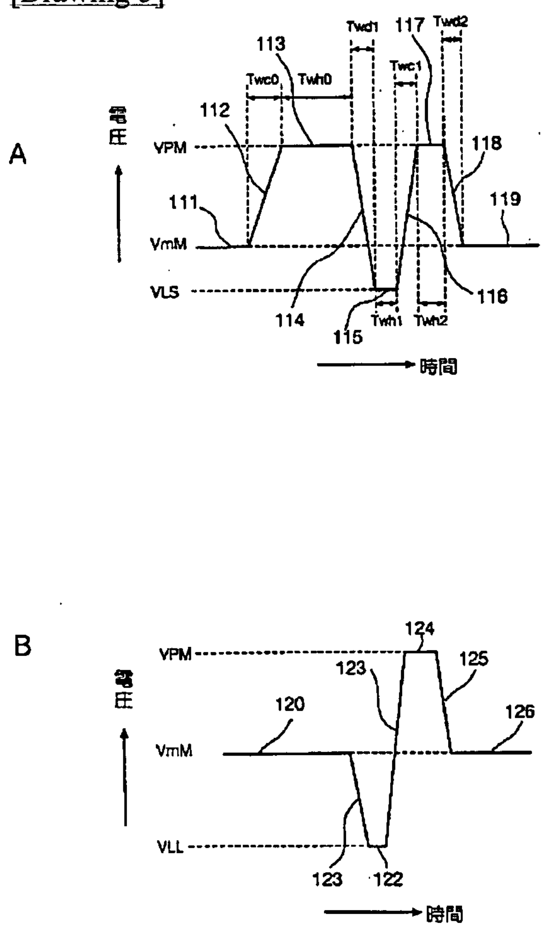


[Drawing 5]



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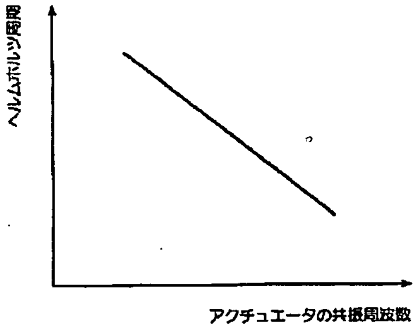
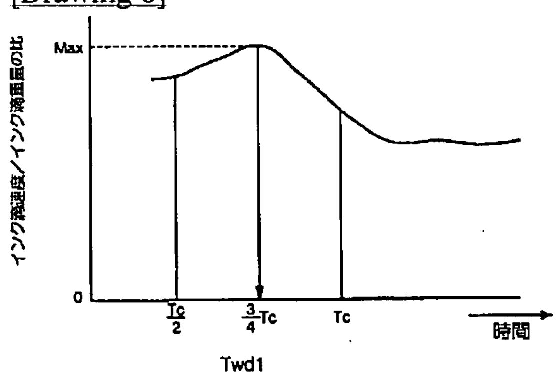
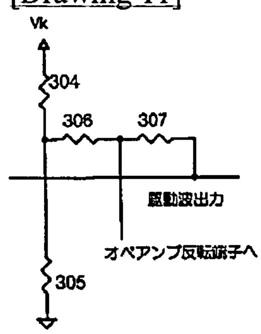


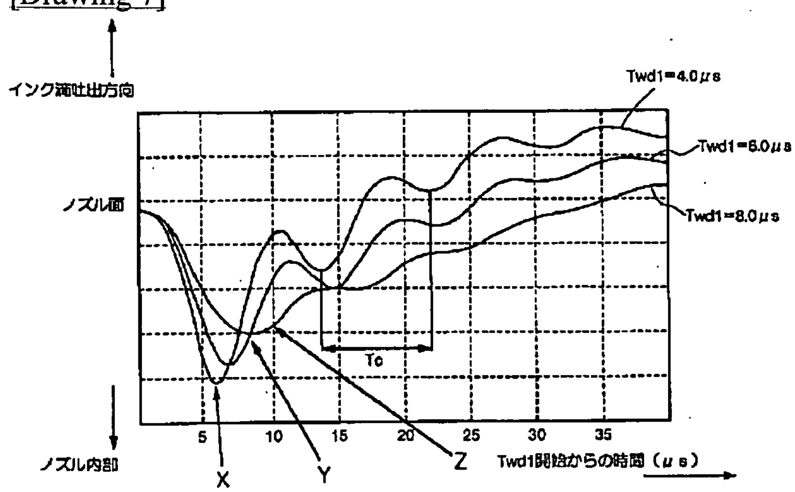
[Drawing 8]



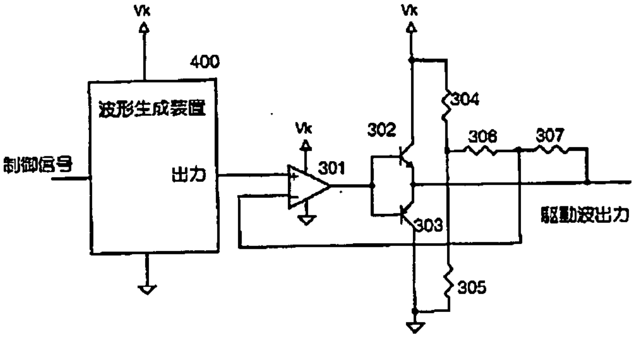
[Drawing 11]



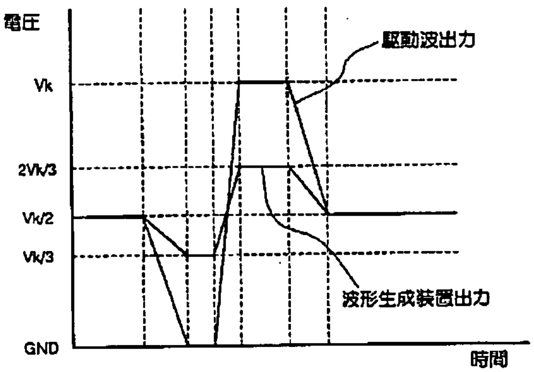
[Drawing 7]



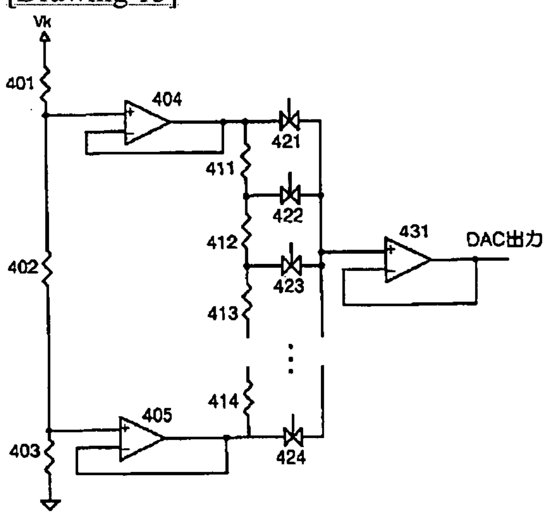
[Drawing 9]



[Drawing 10]



[Drawing 13]



[Translation done.]